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A CRETACEOUS AND LOWER TERTIARY SECTION IN SOUTH CENTRAL MONTANA.

(Plate XXIX.)

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(*Read April 3, 1902.*)

This paper is intended only as a preliminary report of an interesting geological section—an account of what has been done and a suggestion of what is yet to be accomplished. The points of interest are: (1) The completeness of the Upper Cretaceous which overlies the older beds, probably Jurassic and Lower Cretaceous, and underlies the Fort Union, which here contains mammalian remains, correlating it with the Torrejon of New Mexico; (2) the excellent exposures of the strata, giving a good opportunity for study; and (3) the occurrence of interesting fossils, especially vertebrates, in several different horizons.

The region here referred to lies east of the Crazy Mountains and south of the Big Snowies, in the basin of the Musselshell River, in Sweetgrass County. It extends from south of the Musselshell River southward twelve or fifteen miles, and eastward from a line passing southward from Harlowton on the Musselshell about the same distance. This is part of the south limb of a broad anticline, the general trend of which is south of east. This anticline is dissected longitudinally by the Musselshell. The lowest strata exposed are upheaved into a dome-shaped uplift southeast of Harlowton and four or five miles south of the river, where strata which are apparently of Jurassic age are exposed.

This region is on the western border of the elevated plains country, and occupies a position intermediate between the plains and

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the foothills. The strata are, as a rule, not horizontal, but have been affected by the disturbances which have elevated the mountains farther to the west or north. In restricted localities the beds are horizontal and in others nearly vertical, and there are all intermediate grades. The average dip is probably not more than fifteen or twenty degrees.

The relief beautifully expresses the geological character. Through the whole section there are alternations of sandstones and shales and all grades between the two. Sometimes, as in the Fort Benton and Fort Pierre, the shales predominate and attain a considerable thickness. Again, as in the Dakota (?), Niobrara, Fox Hills, etc., sandstones predominate—at least there is enough indurated sandstone to retard erosion and to produce prominent ridges which can be followed for long distances—fifty miles or more. In all the formations there is considerable sandstone, and in all there is much shale; but I have seen but very little limestone in the whole section, though it sometimes occurs in concretions or in thin layers.

It does not appear that during the whole period of deposition the sea ever attained any great depth. Probably it was deepest at times during the Benton epoch, yet even here the great amount of sand in the shales indicates near-shore deposition. The erosion features will be given in the descriptions of the different formations.

So far as I am aware this particular region has been described only by the writer (see *Science*, January 3, 1902, p. 31, and February 14, 1902, p. 272). A little to the west is the area mapped in the Little Belt Folio (No. 56) of the U. S. Geol. Survey, and some work was done to the eastward on Swimming Woman and Careless Creeks by W. Lindgren and George H. Eldrege, in connection with the Northern Transcontinental Survey.[1]

Of course there is no single section where all the features here described can be seen, and the depressions or ridges into which the different strata weather have frequently to be followed for a few miles to obtain good exposures. Fortunately this is easily done.

The Lake Basin, to which reference will frequently be made, is a large, depressed area nearly fifty miles long east and west and twenty-five miles north and south in the widest portion. The former represents the greatest east and west extension. The eastern portion extends northeastward. This portion I have not ex-

[1] *Tenth Census of the United States*, Vol. XV, p. 243.

plored. The basin has no outward drainage, but has several small lakes without outlets, into which small streams empty, when there is an excess of precipitation. The basin is bounded on the south by the high rocky bluffs of the Fox Hills, and on the north, at least in the western portion, by the hard sandstones of the Niobrara and the Dakota (?). The name Lake Basin seems doubly appropriate, for it not only contains lakes, but it resembles the bed of some ancient body of water with bays and inlets, and with capes, promonotories and peninsulas extending into it from the southward. The scene is spread out like a great panorama; the southern hills and northern ridges become hazy in the distance and the farther border seems a dim ridge on the eastern horizon. At the foot of the Fox Hills bluffs are the Fort Pierre shales and still farther away the Fish Creek beds.

As the principal object of this paper is to show something of the characters of the uppermost Cretaceous and Lower Tertiary formations in this locality, and to give a little light tending toward the clearing up of the problem concerning the boundary between the Mesozoic and the Cenozoic ages in the Rocky Mountains, I will give only a brief sketch of the formations lower than the Niobrara.

Jurassic, etc.

The supposed Jurassic is exposed in a dome-shaped uplift, so that the strike of the outcrop is nearly a circle. The beds are sandstones and sandy clays. The latter are largely red in color. This is apparently due to the combustion of coal. There are bones of large *Dinosaurs* and of some smaller reptiles, but they have not been studied. It is possible that this stratum with the sandstones above may belong to the Lower Cretaceous. There are many hundreds of feet of hard sandstones and shales between the fossil-bearing horizon and the Fort Benton. The upper portion probably belongs to the Dakota formation.

The Fort Benton Formation.

These beds and their contained fossils are much like the corresponding ones in other regions. They are principally dark shales with bands of sandstone in the lower portion, and in one place I found a half dozen specimens of *Prionocyclus* Meek in brown concretions in the shales. Higher were *Ammonites*, *Scaphites*, *Inoce-*

rami, small *Baculites* and other *Mollusca*, all of Benton types. These shales weather into ravines between the sandstones of the Dakota below and the Niobrara above.

Niobrara.

In the Niobrara gray sandstones predominate, though there are beds of shale. This differs from the usual character of this formation in most other regions where it has been observed. It has usually been described as being composed principally of limestone and marl, though sometimes containing considerable sand. The sandstones here are very much like some of those of the Laramie, and near the middle portion are seams of coal. In two or three places I looked in vain for any well-preserved plant remains in the carbonaceous shales and in the sandstones above and below the coal, and followed ravines cutting through the prominent sandstone ridges without finding any good fossils. However, about twenty miles to the southeastward a few plant impressions were found—the best of which was apparently a *Sequoia*—in beds which I take to be Niobrara. Undoubtedly, by careful, continued search, a fair collection could be obtained.

In one place, where Mud Creek cuts through the formation, the beds approach near to a vertical position. I should not estimate the thickness to be less than 700 or 800 feet here. It may be more. The sandstones form a prominent ridge where they are much inclined. These ridges are sometimes wooded, though the trees are usually not very large or numerous.

Fish Creek Beds.

Above the Niobrara are beds which I believe to belong to the Belly River formation, but until they are certainly correlated with the latter I give them the above name.

They are best exposed between Fish Creek and Mud Creek, only a few miles from where the latter empties into the Musselshell River. Here they are nearly horizontal, while the underlying Niobrara dips at a considerable angle to the southward. Farther to the east and west I did not notice any unconformity between the two formations. In the above-mentioned locality, where they are horizontal, they weather into "bad land" forms. The material is principally rather soft sandy clay, with hard, almost black concre-

tions and hard sandstone layers. In the latter there are, in some places, plant impressions. The softer layers contain fossil wood, bivalve mollusks, turtles and bones of *Dinosaurs* of the genus *Claosaurus*. The bones are generally petrified and occur also in the dark concretions which also contain plant remains. Though they are, as a rule, excellently preserved, yet sometimes there is what seems to be a good portion of a Dinosaur broken into myriads of little fragments. The beds are probably either fresh or brackish water.

This formation was observed in several places in this region, and in all there were bone fragments; but we found no other equally good exposures. About twenty-five miles to the southeast, in the Lake Basin north of Columbus, the formation lying immediately below the Fort Pierre in one place has a considerable thickness of sandstone containing petrified logs, but only one or two small fragments of bone were found. Some of the plants of this formation are related to *Sequoia*. The bivalve shells were so fragile as to crumble with the soft matrix in which they were imbedded.

Lying over these beds is a series of shales and hard laminated sandstones. Some fossil leaves were seen in the latter. A series of dark shales, perhaps thirty feet thick, was carefully examined. The shales were full of carbonaceous plant fragments, and some fairly good leaves were found in the thin interbedded layers of sand or sandy concretions. I do not know whether these beds should be put in this series or in the Fort Pierre. I think it better to consider them, until they are more thoroughly explored, as belonging to the Fish Creek series.

Fort Pierre.

Above the beds just described are the Fort Pierre shales. This represents a well-distinguished horizon, so well marked by lithological characters and by characteristic fossils that its position is beyond doubt. The description of the Pierre in Colorado, Wyoming, etc., would answer almost equally well for the formation here. Dark, soft shales predominate. There are occasional thin bands of sand and many brownish concretions which break into angular fragments. These sometimes contain marine fossils and sometimes a network of calcite seams. The best preserved invertebrate fossils are in these concretions. The shells are those of *Ammonites*, *Baculites*, *Scaphites*, *Nautili*, and small *Gasteropods* and *Cephalopods*.

Some hard limestone concretions are crowded with these small molluscs.

What distinguishes the Pierre here from that in other places is the presence of many vertebrate fossils. Several *Mosasaurs* have been found. In the summer of 1900, Mr. Albert Silberling and I found portions of two individuals, including a skull. In the summer of 1901, the Princeton Expedition in charge of Dr. M. S. Farr procured a nearly complete skeleton except the skull.

But the most interesting fossil remains are those of the *Dinosaurs*. They have been found to be more numerous here than the *Mosasaurs*. The greater number of them belong to the genus *Claosaurus* and apparently to described species. Two portions of skeletons belong to quadrupedal type, probably to the *Ceratopsidæ*. A *Claosaurus* skull and the greater part of the skeleton was obtained for the Princeton Museum last summer (1901). The digging was easy, but the removal of the bones was slow and tedious, as they had to be hardened. Nodules had formed around some of them, but many were in clear shale. The skeleton was just above a layer of yellowish, partly consolidated sandstone two or three inches in thickness. There were some thin layers or lenses in the shale, in which the remains were imbedded. There was also a minute seam of coal not thicker than cardboard. Cones or ends of twigs of what appeared to be *Sequoia*, Ammonites, Scaphites, Baculites and other molluscs, and shark's teeth were found in the matrix while removing the skeleton. Only the teeth and a few of the shells could be preserved, as the fossils in the shale disintegrated on exposure to the sun and rain. The deeper into the shale excavation was made, the larger the flakes into which it would break. Quite a number of other portions of skeletons were found during this and the previous year. Often the bones are solid, though lying among the grass roots, where the soil is composed of the disintegrated shales. Sometimes the nodules surrounding the bones are very hard and flinty.

The finding of *Dinosaur* remains in these marine beds was unexpected, but the sea was evidently shallow. In some places there is much gypsum in good-sized crystals, or in minute ones scattered through the shales.

The Pierre beds being soft, have weathered into depressions. They are usually covered, except in restricted portions, with a good growth of grass, but are treeless except for a few small willows or

cottonwoods that occasionally grow along the streams. They make grass-clad rolling prairies, with small ravines cutting into the soft shales.

The transition beds between the Fort Pierre and Fox Hills are usually obscured by the material washed down from the bluffs of the latter; but on the ranch of Mr. B. Forsythe, near the head of a branch of Big Coulee Creek, they can be nicely seen. The shales gradually become more sandy, and contain bands of sandstone until the latter predominates and the shales become shaly sandstones or sandy clays. In them I found no trace of fossils.

Fox Hills.

In this formation the hard sandstones form a prominent ridge adjoining the depression made by the Pierre. It is the next prominent ridge above the Niobrara. I have followed its base for about thirty-five or forty miles. In only one place was there any confusion or any difficulty in tracing it, and this was caused by some change in the geological structure obscuring the Pierre shales. The outcrop extends southeast and northwest. It forms the southern rim of the Lake Basin. It furnishes many springs which, uniting their waters, produce little streams that cut through the rocky ridge and flow out upon the Pierre flats. In the Fish Creek region they empty into Fish Creek. In the Lake Basin, if the water does not soak into the ground, they flow into the land-locked lakes. Where the streams form little cañons and ravines through the Fox Hills strata, they are fringed with trees and shrubbery. In little valleys and amphitheatres there are often springs surrounded by groves, which are very picturesque, and in the heat of summer these places form a delightful retreat from the almost treeless wastes around. The trees, which are principally evergreens, cottonwoods, poplars and willows, follow the streams a little way toward the Pierre flats and then disappear.

Though these beds usually appear to be sandstone ridges, yet in places where conditions of weathering are favorable they are seen to contain much sandy clay, and in places for a short distance resemble "bad land" forms.

Fossil leaves and reptilian bone fragments were found in considerable abundance. Dr. Farr brought back some of the fossil leaves, but they have not yet been determined. Most of the bones are too fragmentary to be of much use. Some teeth were recognized as

belonging to *Claosaurus*. The only fossil plant we were able to recognize in the field was a species of *Salisburia*.

Though this is probably still below the Laramie—at least there are thousands of feet of what is apparently Laramie above it—yet this is the highest level in which we found *Dinosaur* remains in this region. This is interesting, as in other regions the *Claosaurs*, with one exception, have come from beds which have been supposed to be above the Fox Hills.

It is not certain just where the Fox Hills ends and the Laramie begins. It is possible that these bones, or at least some of them, are in the lowest Laramie; but as the two formations represent differences in conditions of depositions rather than difference in age, as distinguished by change or progression of the fauna or flora, it is not so essential, except as bearing on the more interesting question of the extinction of a very remarkable class of animals and the occupation of their territory by a class that had for millions of years held a subordinate position.

Above the Pierre, in the Fish Creek region, are alternations of dark shales and gray sandstones. In places the sandstone is warped, twisted or made up of imperfectly concentric layers. Above these are brownish laminated and greenish or brownish unlaminated sandstones and sandy clays. Provisionally, I place the base of the Laramie above these latter beds. They contain fossil leaves and bone fragments.

Laramie.

The lowest beds, which are here taken to be Laramie, are a series of alternating various-colored shales and gray unlaminated sandstones. There are several hundreds of feet of these and no fossils were found in them. There are in some layers brownish concretions, some of which are large and composed of sandstone. These beds form a depression, but not so low as that of the Pierre shales.

Over these lies about an equal thickness of similar sandstones and gray shales. The former are harder and form a bench or ridge. There are several thin seams of coaly matter and the shales hold impressions of ferns and other delicate plants different from what we observed elsewhere.

Near or at the top of this series there are at least two layers containing non-marine fossils. In one of the fossils are principally *Gasteropods* and in the other bivalves—probably *Unio*. It

is said that this layer extends for twenty miles up Fish Creek, but I have not tried to trace it, so do not know whether it is continuous or not. It is also said that these fossils gave the Musselshell River its name. Here we may be quite sure that we are in the Laramie, for fresh or brackish water conditions prevail, but it probably extends between 1000 and 2000 feet below.

Still higher are shales forming a flat or depression, above which are conical hills or hog-backs—the remains of dissected ridges cut through by ravines and by streams which are fed by springs in the Fort Union sandstone above. These hills or ridges are capped with brownish, compact, laminated sandstone. No fossils were seen except fragments of wood in the shale.

Above these sandstones dark shales again predominate. I cannot tell, at least without more careful study and observation, where the Laramie terminates and the Fort Union begins. In fact, it looks as if there were in this section almost continuous deposition from the Jurassic up. We found here no traces of the volcanic material of the Livingston formation, which only thirty or forty miles to the southwest is so well developed. It appears that here deposition went on quietly and uninterruptedly. There is little doubt that part of the strata were deposited synchronously with those of the Livingston. Here, so far as we have discovered, as in other places, Nature has left no waymarks and laid down no boundary line to distinguish between the great "Age of Reptiles" and the "Age of Mammals." There appears to be no sign of the disturbance that is supposed to have closed the Mesozoic and brought in a new order of things; yet only a few miles away there was a region of upheaval and of intense volcanic activity. The strata in the section under consideration have been disturbed, but the Tertiary beds are also involved in the upheaval. Perhaps microscopic or chemical examination may reveal the presence of fine volcanic material here.

Mr. W. Lindgren made three different measurements of the Laramie to the eastward of this region (see *Tenth Census of the United States*, Vol. XV, p. 744). In none of these does he make the thickness of the Lower Laramie to be less than 7000 feet. I do not think that this, as C. A. White[1] thinks probable, includes the Belly River, or anything lower than Fort Pierre. Lindgren's Upper Laramie, or Bull Mountain series, is probably Tertiary—apparently

[1] "Correlation Paper, Cretaceous," *Bull. 84, U. S. Geol. Survey*, p. 174.

Fort Union. What is supposed to be Laramie in the present section is very thick, probably approximating that of Lindgren's measurements. But here, as everywhere else, the boundaries of the Laramie are uncertain. Here, however, we have it confined between certain limits. We have below a characteristic Fort Pierre fauna and above a characteristic Fort Union flora. Just how much of that which intervenes is Laramie is not known. I have no doubt that here deposition was going on at the same time as that of not only the Livingston, but also of the Arapahoe and Denver beds. Whether these beds will ultimately be assigned to the Upper Laramie, or included in a separate formation, depends upon the results of future careful investigation.

TERTIARY.

Fort Union.

The dark shales just mentioned continue upward, changing little in character; but brown concretions become numerous, then layers containing shells of bivalve Mollusca, then occasional layers of sandstone, and above these, often capping the bluffs, heavy gray sandstones, usually hard, sometimes laminated and sometimes massive. Above this I cannot speak definitely, but think that the Fort Union continues much higher. The strata from the top of the bluffs south of Fish Creek, which make a bench sloping toward Sweetgrass Creek in the direction of Melville, perhaps belong to higher members of this formation. The strata are not always continuous for great distances, but vary locally; yet a general description can be given that will apply fairly well to the beds examined. There are dark gray shales that in many places weather to thin, flaky particles on the surface. The wind blows away this light material and leaves bare depressions without vegetation. The sandstones are usually hard, sometimes massive or imperfectly bedded, and in some places break into great blocks, which tumble down the steep sides of the bluffs.

In the Fish Creek region these heavy sandstones, which lie above the soft shales, form a long line of rugged bluffs extending along the south side of the creek from the neighborhood of Porcupine Butte eastward for twenty-five or thirty miles; then it extends southeastward, probably forming the divide between the Sweetgrass on the southwest and the southern branches of Fish Creek and Big

Coulee Creek; but I have not examined all of this territory. I examined hastily the beds on Sweetgrass Creek east and a little north of Big Timber, where I made a collection of fossil leaves. The remains of a turtle were also found in the shale.

The portion of the Fort Union described in this paper apparently represents the upper portion of the Crazy Mountain section, as given by Weed in the *American Geologist* of October, 1896.

Fossil plants, *Unios* and *Gasteropods*, are abundant and may occur in any part of the beds favorable for their preservation. Last summer (1901) determinable Mammalian remains were found. As is well known, the exact position of these beds has been a matter of some doubt and difference of opinion. They have usually been assigned to the Tertiary, though they have been placed as low as the Cretaceous and as high as the Miocene.

The bones and teeth of *Mammals* which were found[1] are not numerous, but are sufficient to show that the beds are of nearly the same age as the Torrejon of New Mexico. They are:

Mioclænus acolytus (Cope).
Anisonchus very near to *A. sectorius* Cope.
Euprotogonia puercensis (Cope).
Pantolambda cavirictis (?).
Pantolambda (?), a small species.
Some others are doubtful.

I felt very certain that these beds were Fort Union, but to settle the matter forever and leave no room for a shadow of doubt, a box of fossil leaves was sent to Mr. F. H. Knowlton, of the United States Geological Survey. Mr. Knowlton examined them at once and sent me a list, which I quote:

Pterospermites cupanioides (Newb.) Knowlton.
Populus speciosa Ward.
Populus amblyrhyncha Ward.
Ulmus orbicularis ? Ward.
Vitis xantholithensis Ward.
Populus daphnozenoides Ward.
Populus arctica ? Heer.
Platanus aceroides Göpp.
Celastrus sp.
Grewia crenata (Ung.) Heer.

[1] *Science*, February 14, 1902, pp. 272, 273.

Viburnum asperum ? Newb.
Populus cuneata Newb.
Populus sp.
Platanus nobilis Newb.
Platanus basilobata Ward.
Viburnum sp.
Paliurus sp.
Grewiopsis viburnifolia Ward.
Populus ? n. sp.

Mr. Knowlton says: "The species are all Fort Union beyond a doubt."

Of a few shells which I enclosed, he writes: "The shells I showed to Mr. Stanton, and he says that the two large ones are *Unio Couesi* White; and the other pretty near to *Unio Endlichi* White."

The *Mammals* were found in the shale. The collection of fossil leaves was made in the sandstone a little higher up, though there are concretions and layers of sandstone that contain leaves in the same beds as the Mammalian remains. A portion of the collection was obtained on Sweetgrass Creek north of east of Big Timber, in the locality mentioned above.

General Observations.

The problem of greatest interest connected with the study of this section is that relating to the transition from Mesozoic to Cenozoic times. Of course, if deposition had been continuous, or nearly so, and there were no great faunal or floral migrations, there could be no distinct boundary between the two. There is a great difference between the Cretaceous as a whole and the Tertiary as a whole, but where are we to draw the line? If there was a time of widespread or general upheaval throughout the western portion of the continent, or of the Rocky Mountain region, this might form a convenient division. Upheavals and great volcanic activity certainly occurred in restricted localities, but we cannot at present prove that such were general or that they did not occur in different places and at different times. If we could point to any time when the *Dinosaurs* ceased to be and the higher orders of *Mammals* took their places, then the matter would be easy; but heretofore most of the Cretaceous *Dinosaurs*, in fact nearly all of them, have been

supposed to come from the uppermost portion of the Cretaceous—the Laramie—but the other fossils found in these beds have not been of a character to settle the doubt concerning the horizon. There is no direct proof that the Dinosaurs died out before higher forms of Mammals became numerous. Though they have not yet, so far as I know, been found in the same beds, yet there seems good reason for believing that Dinosaurs were contemporaneous with Puerco Mammals. Were it not for the "Ceratops fauna" and the discovery of a few specimens in the eastern United States and one in Kansas, we should say that the Dinosaurs died out at the end of the Jurassic. It would seem that if anything had a chance of being preserved it would be the large, solid bones of these animals; yet there are miles of thickness of strata and thousands of square miles of exposure of Lower Cretaceous, Dakota and Colorado beds, and nothing, I believe, has been found to tell that these animals still lived in this great Cordilleran region, except the type of *Claosaurus agilis* from the Niobrara of Nebraska. This rock must represent many millions of years in which Dinosaurs lived, flourished and progressed. To our view they disappear in their glory, and after ages appear again in glory but transformed; again they suddenly disappear and we see them no more. The morning, midday and evening of their splendor is lost to us. Until the discovery of the beds described in this paper almost nothing was known of them in the Montana formation, at least the beds from which they had been collected had not been considered as belonging to that age. The point the writer wishes to make is this: It is extremely unsafe to say when and where these strange reptiles breathed their last, for the presence of fossils is certain evidence of the existence of life, but the lack of them is no evidence of its absence. Dinosaurs may have continued long in the Eocene, but conditions in the places where so many Mammalian remains have been found may not have been favorable for them.

I think we can hardly account for the general absence of Dinosaur remains in the Kootenai and Upper Cretaceous, below the Laramie, by the beds being in part marine. Much of the strata is evidently fresh or brackish water. We should hardly expect to find them in the Benton and Fort Pierre shales associated with large marine Mollusca, yet as previously stated *we do find them* in the latter. This proves that these animals lived near the sea or where they could float into it. Why don't we get them then in the many

thousands of feet of sandstone which, if marine, must be near-shore deposits? It is true that any day we may hear of their being found in some of these strata, and we may also hear of their being found in Eocene strata, if they have not been found there already.

As shown by this paper, the presence of *Claosauridæ*, and probably of *Ceratopsidæ*, is far from showing that the beds in which they are found are as late as Laramie—I mean as the Laramie as it is understood. It is true that the Fort Pierre, and in some places the Fox Hills with it, represents an incursion of the sea, and that conditions of life were not greatly different during the time of the deposition of the Belly River beds from what they were in the Laramie.

At present the fossil plants, together with orographic movements and their results when they occur, are the only things we can use to distinguish these doubtful formations as the Laramie, Livingston, Denver, etc. The plants, on account of mixtures of the flora of different horizons in collecting, have not been available for use until the material has been carefully separated. As Mr. Knowlton has been doing this work, his forthcoming monograph on the Flora of the Laramie and Allied Formations will be looked for with interest.

There is not much doubt that the Livingston in Montana represents the upper portion of what has been called the Laramie in the plains region farther to the east. Both have Laramie strata below; both are overlaid by Fort Union beds. In Colorado it seems that the Arapahoe, and probably the Denver, or the greater part of it, sustains the same relation to Laramie. Mr. Knowlton says: "From these considerations it appears beyond question that the flora of the Livingston formation finds its nearest relationship with the Denver beds of Colorado."[1] If the Livingston and Denver are of the same age, as has for some time been suspected, then the Denver must be older than the Fort Union, and therefore older than the Torrejon. With its apparently Cretaceous Vertebrate fauna, we are not warranted at present in placing the Denver much higher than the Livingston. It may be in part contemporaneous with the Fort Union.

The Puerco should be nearly of the same age, as it lies between Laramie and Fort Union (Torrejon) strata.

Below is given a table which is intended to show the probable

[1] *Bull. 105, U. S. Geol. Survey*, p. 63.

relations in time of the formations under consideration concerning which there is doubt:

Table Showing Probable Relations of the Laramie and Overlying Beds in Different Regions.

	Cretaceous.	*Tertiary.*
In Wyoming	Laramie of King	
Plains of Montana	Laramie	Fort Union
Crazy Mts., Montana	Laramie · Livingston	Fort Union
Denver Basin	Laramie Arapahoe Denver	
Puerco River, N. Mex.	Laramie Puerco	Torrejon

The names given are the ones by which the different divisions have been called. There does not seem to be much doubt that the Livingston, Denver, Puerco, etc., are contemporaneous with what in other places has been assigned to the upper portion of the Laramie. Whether all will be included in the Laramie later will depend on the results of further careful investigation. I have indicated the doubtful division between the Cretaceous and Tertiary by a dotted vertical line passing between the Livingston and Fort Union and between the Puerco and Torrejon, or approximately so, not claiming that the time division line between the two sets of strata would fall exactly in the same place. The horizontal parallel lines are intended to represent contemporaneity of deposition. Deposition in the Denver Basin was not continuous and the blank spaces indicate non-deposition. The broken or dotted lines indicate probable continuity.

Remarks on the Fossil Mammals.

The mammals are represented by about a half dozen species. Five of these are represented by teeth. Almost any one of these

taken alone would strongly incline one to the belief that the formation containing them is contemporaneous with the Torrejon of New Mexico. This is made still stronger by nearly every specimen. There are a radius and ulna which are different from any found in New Mexico, so that they cannot be assigned to any genus with certainty, and there is a premolar much like that of Pantolambda, but indicating an animal much smaller than any species of that genus, to which, however, I refer it with doubt. The other four are cogeneric if not cospecific with Torrejon forms.

Mioclænus acolytus (Cope). (Plate XXIX, Figs. 9 and 10.)

This is represented by a small portion of a mandible with a molar tooth which is almost unworn. The anterior cusps are connate at base and much higher than the posterior ones.

Anisonchus Cope. (Plate XXIX, Figs. 3–5.)

This is also represented by a portion of a mandible. There are two teeth, a fourth premolar and a first molar. They are of nearly equal length. In size and character the teeth are nearly like *A. sectorius* Cope. It may, however, be another species.

Euprotogonia puercensis (Cope). (Plate XXIX, Figs. 6–8.)

Represented by a third premolar and a second molar of the right side and a third molar of the left. The molars differ somewhat from the type. Matthew has carefully studied the many specimens in the American Museum collection and finds a wide range of variation in the teeth, but no constant characters that will serve to separate the various forms which Cope has named. Of the many specimens no two appear to be exactly alike. I have compared the present specimens with those in the above collection and find that they do not differ so much from some of the American Museum specimens, as the latter vary among themselves. What comes nearest to being a distinguishing character is the smallness of the hypocone as compared with the protocone, but this is at least *nearly* paralleled by some of the above-named specimens.

Pantolambda (?) (Plate XXIX, Figs. 1, 2, 14.)

There are the greater portions of a radius and ulna, and two phalanges which are different from anything described from the

Torrejon. They more resemble in some respects the corresponding bones of *Coryphodon*.

The ulna is much larger than the radius, is broad antero-posteriorly but narrow transversely. The upper portion of the olecranon is broken off, but a cross section above the glenoid cavity is triangular with the anterior edge thin. The sigmoid cavity is convex transversely. The outer portion is much less convex longitudinally than the inner; it extends lower and its upper portion makes an oblique emargination on the outer side of the olecranon. There are two fairly large surfaces for articulation with the radius. The upper outer surface of the bone has a quite deep longitudinal furrow which dies out near the middle of the shaft. The inner surface is longitudinally concave from the olecranon to the enlargement near the distal end of the bone, where there is considerable swelling and roughening. The distal articular surface is elliptical, slightly concave palmo-dorsally and convex transversely. This surface is very slightly oblique to the long axis of the bone.

The radius is subcylindrical above. The head is partly broken, but the surface for articulation with the humerus is shallow and appears to have been nearly circular. There is a longitudinal roughening on the ulnar side, to correspond with similar rugosities on the radial side of the ulna. Below these is a rugosity on the antero-inner side of the radius and on the opposite side. The bone has the appearance of being twisted on itself. The form of the bone suggests freedom of motion of the limb other than a fore-and-aft movement.

A proximal and medial phalanx apparently do not differ greatly from those figured in Osborn's paper on "Evolution of the Amblypoda."[1]

	M.
Length of ulna from upper portion of glenoid cavity	.1970
Antero-posterior diameter at middle of shaft .	.0310
Transverse diameter at middle of shaft . .	.0143
Transverse diameter of shaft of ulna at middle .	.0195

Pantolambda cavirictis Cope (?).

Fragments of upper jaw, with teeth from which enamel has been removed. The size is nearly the same as the corresponding teeth

[1] *Bull. Amer. Mus. Nat. Hist.*, Vol. X, p. 187.

of *P. cavirictis*, and there is nothing to distinguish it from that species.

Pantolambda (?) sp. (Plate XXIX, Figs. 11–13.)

An upper premolar, much smaller than P^4 of *P. bathmodon* or *P. cavirictis*, but it is possible that it may be a P^3 of nearly as large a form. It is very doubtful, however, whether it belongs to *Pantolambda* at all. The protocone is more conical, the outer slope on the median line of the tooth is steeper and the inner less so. The outer surface near the base of the crown is more concave.

A canine found with the above is not like that of the known species of *Pantolambda*, but can hardly be distinguished from that of modern Carnivores. It probably belongs to some Creodont.

PRINCETON UNIVERSITY, May 24, 1902.

EXPLANATION OF PLATE XXIX.

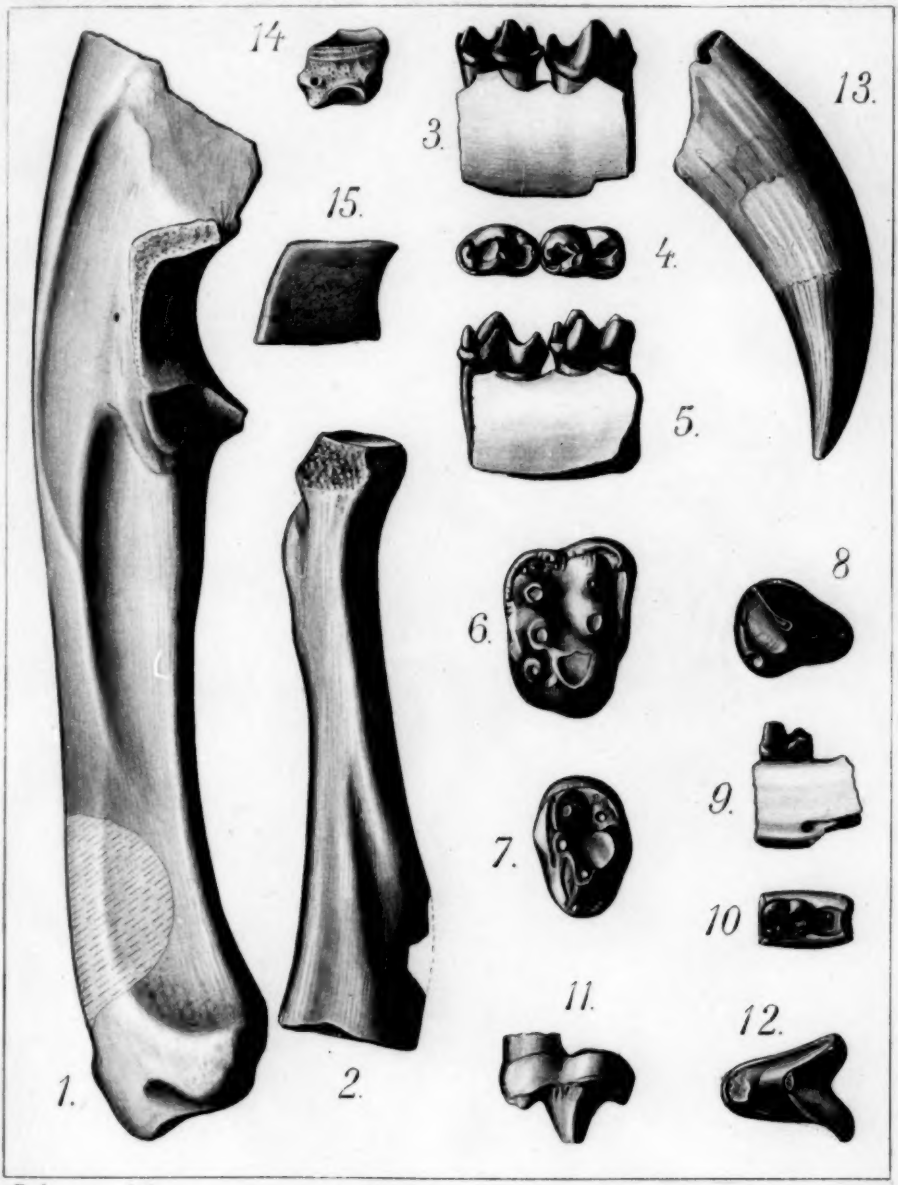
FIGS. 1 and 2. Ulna and radius possibly belonging to some species of *Pantolambda*. ⅓ natural size.

FIGS. 3–5. *Anisonchus sectorius* (?)
Last lower premolar and first lower molar with portion of mandible. Outer and inner view of mandible and upper view of teeth. × 2.

FIGS. 6–8. *Euprotogonia puercensis*.
6. Right upper second molar. × 2.
7. Left upper third molar. × 2.
8. Right third upper premolar. × 2.

FIGS. 9, 10. *Mioclænus acolytus*.
A lower molar with portion of a mandible. × 2.

FIGS. 11–15. *Pantolambda* (?). Upper premolar. × 2.
13. Canine tooth found with 11.
14. Phalanx found near 1 and 2. × ⅔.
15. Scale of *Lepidosteus* found with mammals. × 2.



Fv Iterson del.

FORT UNION MAMMALS.

AREOGRAPHY.

BY PERCIVAL LOWELL.

(*Read April 4, 1902.*)

1. Facts familiar to the specialist are often credited with a general appreciation they do not possess. Immersed in his own line of research, the investigator forgets that others are not as intimate as he with some of the fundamental points of his inquiry, and omits as truisms what to others are not even known for truths. Areography is such a subject. Probably no one outside of the pursuit is aware how cogent is the conclusion to be derived from an inspection of the maps that have been made of the planet, as to the reality and the relation of the markings there depicted. Nor was it indeed till after I had compared these maps with some particularity that certain deductions from them forced themselves upon me. It will perhaps, therefore, not be unproductive of result if I present at this general meeting a collective view of the maps which have from time to time been made of Mars and note what they imply. Maps speak best for themselves, and with very slight introduction can be made to tell their own story better than any amount of text.

2. Of the maps here brought together, the earlier are taken from Flammarion's thesaurus *La Planète Mars*, Proctor's Dawes' map from his own book, Schiaparelli's from his memoirs in the Accademia dei Lincei, and the later ones from my own work. Of these latter, that for 1896–97 is the result of my own synthesis of the Flagstaff and Mexican observations of the Lowell Observatory for those years, while the ones for 1898–99 and 1900–01 I have but just completed, and they appear here for the first time.

3. All the maps here given marked in their day the point that areography had then reached. With but two exceptions, that of Flammarion and Proctor, therefore, they represent original observations made by the maker of the map himself or under his direction, and show in procession the evolutionary development of the subject. Such maps as failed to add to existing knowledge and are valuable merely as confirmatory documents have not been included. On the other hand, no map which materially contributed anything has been left out. Many excellent charts, therefore, have had to be omitted, not always because they presented nothing new, but

because contemporaneous ones included practically all their discoveries with additions. Of these, Cerulli's maps of 1896–97 and 1898–99 and Flammarion's of 1900–01 deserve special mention. The omitted maps confirm, not invalidate, the conclusions here drawn.

4. Twelve maps constitute the series. Of these the ordering chronologically runs thus:

I.	Map of Beer and Mädler	1840
II.	Map of Kaiser	1864
III.	Map of Dawes, by Proctor	1867
IV.	Map résumé by Flammarion	1876
V.	Map of Schiaparelli	1877
VI.	Map of "	1879
VII.	Map of "	1881–82
VIII.	Map of "	1883–84
IX.	Map of Lowell	1894
X.	Map of "	1896–97
XI.	Map of "	1898–99
XII.	Map of "	1900–01

Mercator's projection is used in all the maps. The zero meridian is in the same point on the planet in all except Kaiser's, though that meridian does not always fall on the same part of the plate, being in I, IX, X, XI and XII on the extreme left, in III, IV, V, VI, VII and VIII in the centre. Beer and Mädler's map is given by Flammarion on a stereographic projection which, for the sake of inclusion in the present series from its age and chronological importance, has been changed to Mercator's. All other circumpolar projections have been omitted.

5. It will be seen from inspection of the maps, and would be simply corroborated by further additions to the list, that increase in our knowledge of the surface of Mars falls naturally into four divisions or stages of development. The first of these is pre-cartographic; the second extends from 1840 to 1877; the third from 1877 to 1892; the fourth from 1892 to the present day. The first three of these divisions correspond to those given in Flammarion's *La Planète Mars*. The fourth is since the publication of that book.

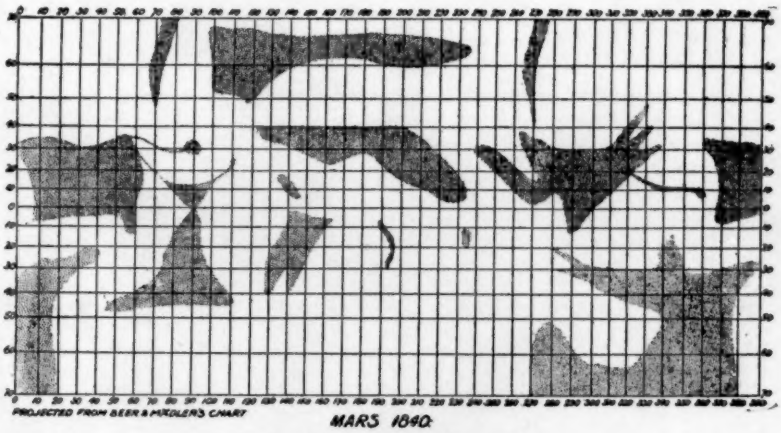
6. Near the end of the several periods are observations which mark the dawn of the next to come, making as they do adumbration of phenomena clearly to be revealed in the succeeding stage. Though not themselves the detection of details which characterize

the period, they make transition to them. Dawes thus made twilight to the third period in 1864; W. H. Pickering and the Lick observers to the fourth in 1892.

7. Distinct phenomena characterize the three periods. Patches of light and shade make the markings shown on the maps of the first stage of cartography. Of a piece though these patches are, their shapes appear well defined. At first one might suppose such to be due to the handicraft of the draughtsman and to possess no scientific value. But inspection of the several charts, one after the other, shows that the shapes are not artistic embodiments of ill-seen shadings, but are intrinsic traits of the shadings themselves, for chart after chart reproduces the same turns and twistings.

8. To see this we have but to take up in sequence the maps from 1840 to 1876. No. 1 of the series shows a cordon of patches

FIG. 1.

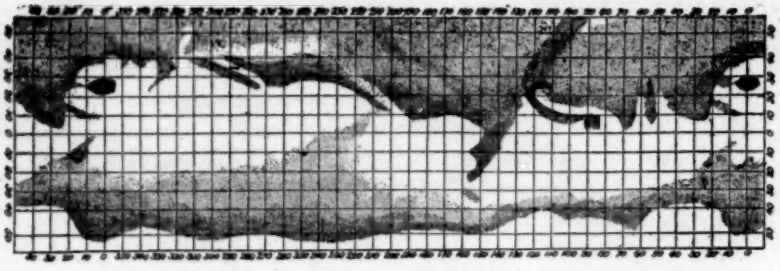


Map of Beer and Mädler, 1840.

stretching round the map at about 30° south latitude. Their height is greatest at 90° of longitude, and from this slopes down through 360° to 20° longitude, whence it gradually rises to the maximum. At the point of maximum is an oval marked out by broad shading on the south, by narrow penciling on the north, and holding a roundish dark spot in its centre. This is the Solis Lacus, the eye of Mars. To the right of it follows a leech-like patch, the Mare Sirenum and the Mare Cimmerium seen as one. After this comes

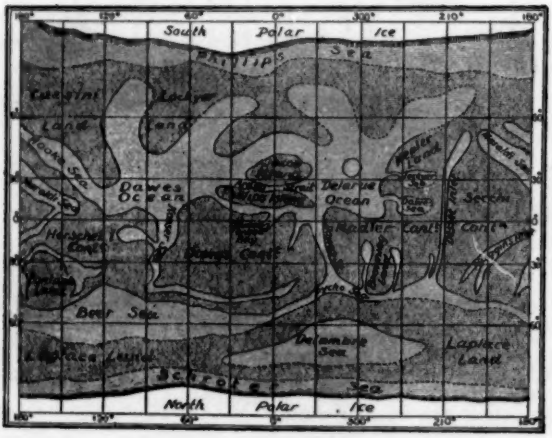
a large dark area in the shape of a funnel, the Syrtis Major. Then a ribbon ending in a scroll, the Sabaeus Sinus, the adopted zero point of Martian longitudes.

FIG. 2.



Map of Kaiser, 1864.

FIG. 3.

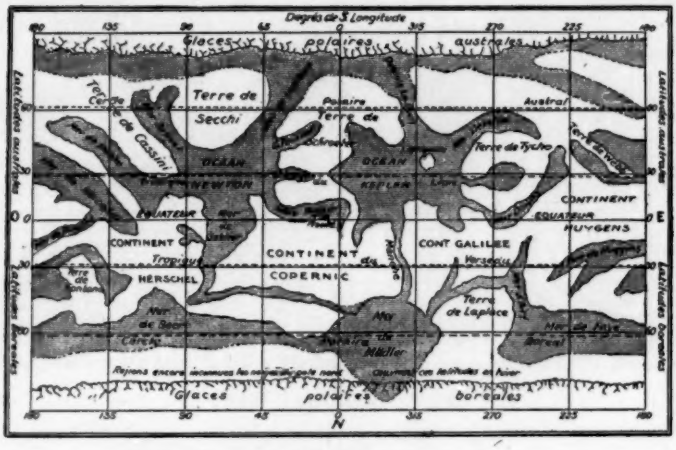


Map of Dawes, by Proctor, 1867.

9. In map No. 2, Kaiser's, all these features can be followed, from the eye with its eyebrow and the curve of its lower lid down through the chain of seas back to the oculus again. The various other dark markings on the map can be similarly identified.

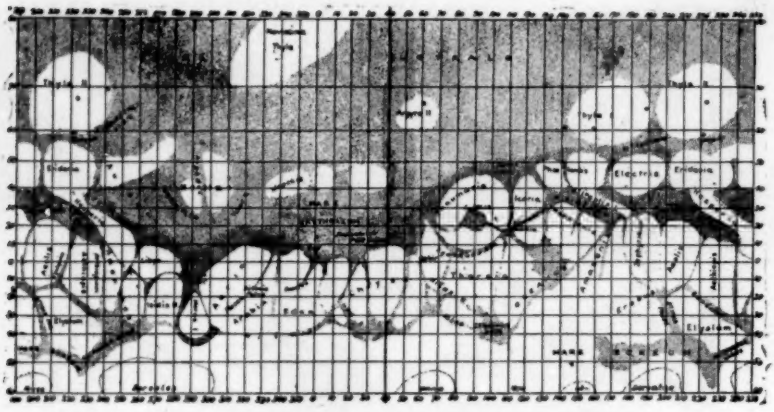
10. A very different set of phenomena stamps the advance made in the second period. Over the bright portions of the map is now drawn a network of fine lines. The dark patches remain as before. These singular lines are what are known as the "canals" of Mars.

FIG. 4.


Glaces polaires australes
Terre de Secchi
Terre de Tycho
OCEAN
NEWTON
KEPLER
CONTINENT
EQUATEUR
HUYGENS
CONTINENT
CONT GALILEE
CONTINENT
COPERNIC
HERSCHEL
Terre de Laplace
Mer de Beer
Mer de Maraldi
Mer de Lockyer
Mer
Mer de Hall
Mer de Main
Mer de Knobel
Mer de Dawes
Mer de Secchi
Mer de Huggens
Mer de Kepler
Mer de Galilée
Mer de Copernic
Mer de Herschel
Mer de Laplace
Mer de Lockyer
Mer de Beer
Mer de Maraldi

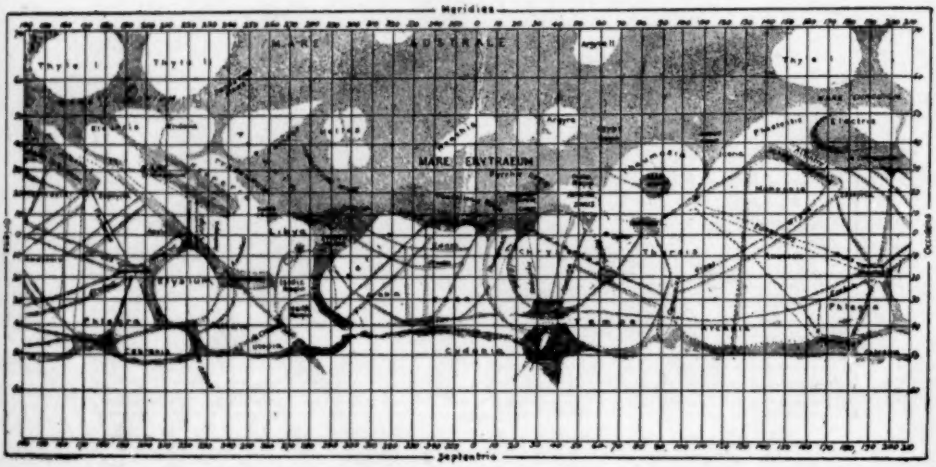
After the opposition of 1883–84 he drew only maps with the pole for centre, because of the tilt of the Martian axis which exposed the northern regions and hid the southern ones.

FIG. 6.



Map of Schiaparelli, 1879.

FIG. 7.

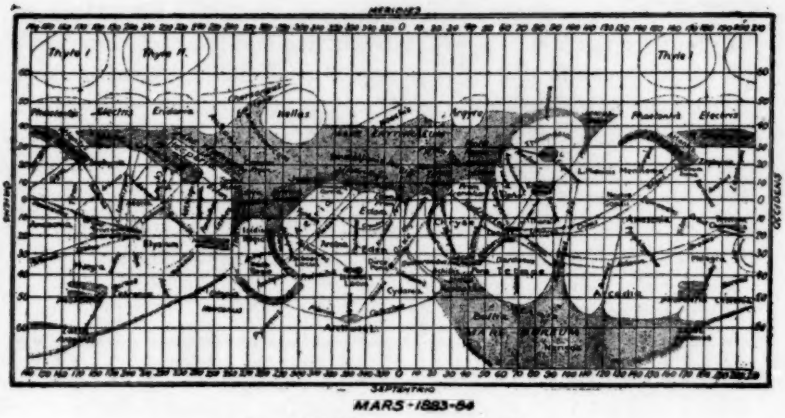


Map of Schiaparelli, 1881–1882.

The distinctive features of these maps are the "canals." The

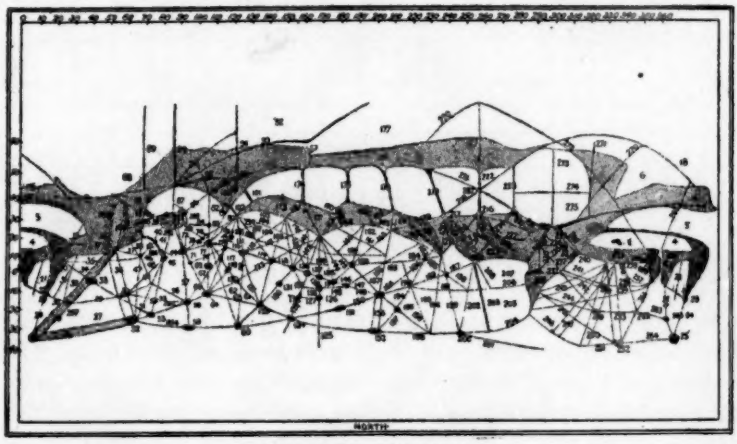
"canals" are objects as technical in character as they are in name, being quite unlike any other planetary detail. They are narrow lines of uniform width, of uniform direction and following usually

FIG. 8.



Map of Schiaparelli, 1883–1884.

FIG. 9.



Map of Lowell, 1894.

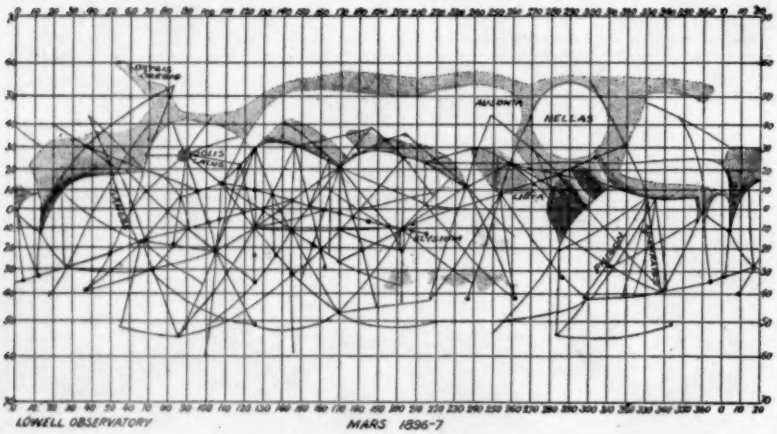
the arcs of great circles. Tenuity, regularity and intercommunication are the traits which make them *sui generis*. Such precision

is of their essence. But the observations necessary to its appreciation are not easy. Probably even to-day not above a dozen persons have seen the canals well enough to make their opinion on the subject of weight, but all who have done so agree in their dictum.

12. As with the first and second periods, so with the second and third there was a transition state between the two. What Dawes had done for the first gap, W. H. Pickering and the Lick observers did for the second. In 1892, at Arequipa, Pickering found irregularly narrow markings in the midst of the then called seas, and the Lick observers detected "streaks" in the same regions. These played much the same part, though in the case of the Lick observers much more, to subsequent work that the Dawes' markings had to Schiaparelli's, so far as "canal" detection is concerned.

13. For in 1894 Mr. Douglass at Flagstaff found that the irreg-

FIG. 10.

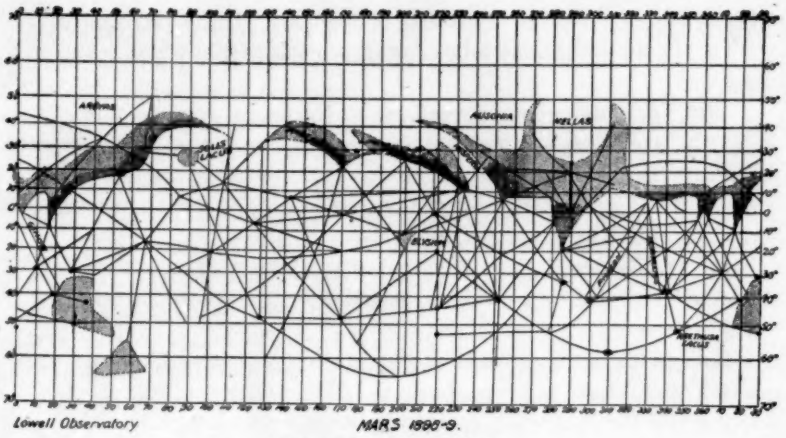


Map of Lowell, 1896–97.

ular lines of Pickering and the streaks of the Lick observers were foreshadowings of something much more peculiar. He found that a system of lines of the startlingly regular character which gives to the "canals" their technical interest, overspread the whole of the great southern dark areas. Thus the third period marks the detection of "canals" in the dark regions, and from that a complete change in the character of the seas, already in part so ably detected by Pickering. Furthermore, the network of each system showed

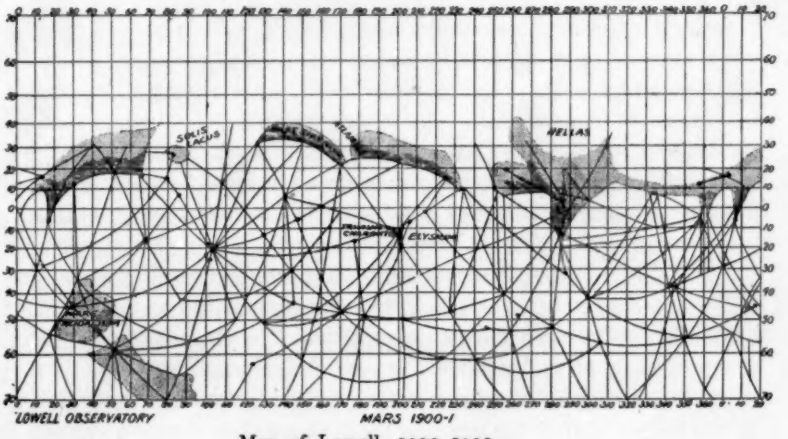
itself to be knotted with spots at its intersections. Many of the spots in the bright regions were detected by Pickering in 1892. Lastly, the two systems turned out to be connected together, the

FIG. 11.



Map of Lowell, 1898–99.

FIG. 12.



Map of Lowell, 1900–1901.

one system running into the other and marked by nick-like points in the coast line, thus making one united mesh of lines and knots superposed over the whole surface of the planet.

14. The history of areography may be thus summed up:

1840–1876. Period of detection of large dark and light markings on the surface of the planet.

1877–1892. Period of detection of "canals" in the bright regions.

1892–1902. Period of detection of "canals" in the dark areas.

15. Three deductions follow an inspection of the whole series of maps:

I. The fundamental agreement of the series.

This is evident at once, but can perhaps be made more so by placing the later maps at a greater distance from the eye, upon which the fainter markings take on the look they would wear were the planet less well seen.

16. II. Evidence that the regularity of the "canals" was not due to predisposition on Schiaparelli's part, but was forced upon him by the objects themselves.

Comparing his own maps on the subject, it appears that an evolution took place in his perceptions. His first map, that of 1877, represents the "canals" as straits, more or less irregular, running up into the land. His next, made in 1879, depicts them narrower, straighter and decidedly more peculiar. That of 1881–82 shows them as fully developed geometrical designs, a character they never afterward lose.

Now, the fact that his representations of the canals grew in regularity as time went on, proves such character to have been no imputation on his part. Had he imagined it, he would have depicted the canals so to start with. As it was, increasing familiarity compelled him to recognize features which he had at first consciously or unconsciously ignored. We have here, indeed, a record left by himself of his own conversion to belief in the very qualities that make the canals so difficult of credence.

17. III. Evidence of an evolution in the detection of the markings from simple to complex. A steady progression in the matter of detail can be traced from its beginning to its end. And the progression is in increasing order of difficulty. The large dark patches are the easiest of detection, the Schiaparellian "canals" in the bright regions the next so, the "canals" in the dark regions the hardest. This is conclusively shown by the number of times each class was seen in the many drawings made at Flagstaff. It is here also evidenced by the way each map, while adding to, also corroborates its predecessor.

SYSTEMATIC GEOGRAPHY.

BY W. M. DAVIS.

(*Read April 3, 1902.*)

1. Geography lacks System.
2. The Value of Systematic Geography.
3. The Content of Geography.
4. Physiography and Ontography.
5. Comparison of Geography with other Sciences.
6. Subdivisions of Physiography.
7. Classification of Land Forms.
8. Physiographic Classification involves Explanation.
9. Explanation involves Past History.
10. Value of Ideal Geographical Types.
11. Service of Deduction in Geography.
12. Contrasts of Biological and Physiographical Classifications.
13. Examples of Explanatory Description.
14. Distinction of Geography from Geology.
15. Dangers of Explanatory Description.
16. Framework of Physiographic Classification.
17. Complexity of Geography.
18. Relation of Physiography and Ontography.
19. Subdivisions of Ontography.
20. Regional Geography.
21. Conclusion.

1. *Geography lacks System.*—Geography has not as yet taken so much advantage from a systematic classification of the facts with which it is concerned as is the case with the biological sciences. The botanist or the zoölogist is greatly aided in observation and in description by the effort to refer every organic individual to its proper place in a comprehensive scheme of classification, whereby its relationships and its contrasts are most concisely set forth; and if he is for a time puzzled by a new species or by a form of uncertain position, he does not for a moment waver in his belief in the value of the principles of classification, but draws encouragement from the aid that it has already given him and perseveres until the systematic position of the new or uncertain species is made clear. The geographer on the other hand makes no such habitual use of

systematic methods. The classification that he uses is immature and imperfect; many classes of geographical problems are as yet hardly classified at all. It is with the intention of showing the need, the possibility and the value of systematic work in geography that this essay is presented.

If a geographer should come upon such an item as one of the narrow flood-plain scrolls sketched in Fig. 1, he might treat it in either one of two ways. He might describe it empirically as a local item of earth form, unrelated to all other items; or he might more or less consciously refer it to some appropriate place in a general scheme of geographical classification, whereby its origin and relationships would be made manifest. The geographer at

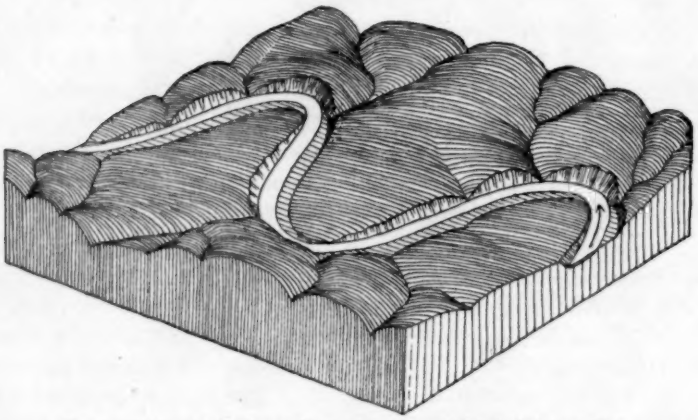


FIG. 1. A meandering valley with narrow flood-plain scrolls.

present generally attempts to pursue the second plan, as would be indicated by the use of such a descriptive phrase as "a narrow strip of flood-plain"; for the term "flood-plain" has a technical meaning and suggests that the observed example belongs with other more or less similar examples in a recognized class of geographical forms. If however we should question different geographers as to the relation of narrow flood-plain scrolls to flood plains of other forms, and as the rest of the scheme of classification in which flood plains form a single group, no approach to agreement would be found; for the venerable subject of geography has not yet established a well-coördinated system of classification for the

facts with which it is concerned. The classifications commonly employed are too often inconsistent, incomplete and immature—inconsistent in their different parts even as to the larger principles upon which their subdivisions are based; incomplete in not including nearly all the categories of facts which properly belong under geography; and immature in making too often only a small advance over the method and terminology of school days. The narrow flood-plain scrolls, such as are shown in the figure above, and such as exist in remarkably perfect development in the valley of the North Branch of the Susquehanna, would according to the methods of geographical description and classification usually current be given no sufficient statement as to their form, no adequate explanation as to their origin, no appropriate discussion as to their correlation with adjacent features, and no systematic treatment as to their share in constituting the physical environment of their organic inhabitants. Yet the flood-plain scrolls deserve due consideration in all these respects from any one who would clearly portray the geography of their district. Lack of consideration is not due to any serious difficulty that inheres in the systematic treatment here suggested, but simply to the habitually unsystematic character of geographical study.

It is the same with the organic items of the broad subject of geography. A farm or a village, a thicket or an ant-hill, a city on a bay or a road over a mountain range is too often mentioned as if it were an isolated and ultimate fact, rather than as if it were a member of a class, exhibiting the peculiar response of certain kinds of organisms to their surroundings. Correlation between the environed organism and the physical environment is coming to be recognized as an essential part of geographical study, yet correlation is not habitual in the treatment of the organic division of the subject by those who would wish to be considered geographers; and as to classification of the correlations, there has as yet been made hardly a beginning. Still it can hardly be doubted that all organic responses are susceptible of a reasonably systematic grouping in relation to one another, and that every example would be better seen and appreciated if it were viewed in association with its fellows.

2. *The Value of Systematic Geography.*—It may be urged with much confidence that fuller attention to such items as narrow flood-plain scrolls, or to any one of the innumerable organic examples

that might be instanced, would be secured if geographers were habituated to treat all such items as forming parts of a whole, and to place every item in its proper place with respect to all others in a well-arranged system of classification. It is sometimes the case that the labors of the systematist are decried; but it is only when systematization is the master and not the servant of the investigator that it merits condemnation. The orderly arrangement of the events in the earth's long history is the goal of all geological study; for the facts of physical and structural geology must be dated in terms of geological chronology if their true relation is to be appreciated. So with geography: it stands to reason that any logical scheme for the classification of all the elements that constitute the content of geography would be of practical value in treating the innumerable items with which the geographer is concerned. The object of such an arrangement would not be to put facts away, out of sight, but to expose them in orderly fashion so that they can be most readily seen, to arrange them so that they shall illuminate and be illuminated by their neighbors. A result of double value would thus be gained. Every fact would be seen in logical relation to its fellows, and its fellows would be seen in logical relation to it. The attention of the geographer would thus be directed to a broadened consideration of correlations, instead of being allowed to limit itself to a narrow view of isolated and unrelated items. The work of the observer in the field would be greatly aided by the presence in his mind of an ideally full treatment for every kind of item that he encounters; unless indeed he has the good fortune to come upon an item previously unknown, and in that case the habit of systematic description already formed would come to his assistance in the effort to gain a full understanding of the novel element. There is no other means by which the general principles, the underlying philosophy of geography, can be so clearly set forth as by systematic classification.

3. *The Content of Geography.*—The first step in an attempt at classification requires an understanding as to the content of geography as a whole. Here at the very outset no general agreement can be expected to-day; but it is well to note that general agreement will probably be reached by following the trend of the progress by which geography has passed through two stages, now to enter upon a third stage of development. A hundred years ago, geography was the study of the earth and its inhabitants; explanation then

made a very small part of description, and even a teleological correlation of the organic and the inorganic divisions of the subject had not been introduced as a well-defined characteristic of its methods. With the progress of science during the nineteenth century, explanation came to constitute a larger and larger share of the descriptive chapters of geography; and from the time of Ritter, geography has been very commonly defined as the study of the earth in relation to its inhabitants, the relationship being exposed during the second stage of progress in the light of teleology, of which abundant traces may be seen to this day.

The third stage of geographical progress is marked by the introduction of two new principles during the last third of the nineteenth century. It thus came to be recognized that explanation must be systematically sought for in every department of the subject; for river courses as well as for winds and ocean currents; for moraines as well as for sand dunes; and it is further recognized that the relationship existing between the earth and its inhabitants must be explained under the broad principles of evolution. The earth with its lands and waters was not arranged for the convenience of its inhabitants; its inhabitants have had to learn, by more or less conscious experiment, to live upon the earth as they found it. As in so many other sciences, the evolutionary philosophy is of enormous practical import in geography. If the earth has not been expressly fitted to the convenience of its inhabitants, but if the inhabitants have had gradually to fit themselves to their slowly changing surroundings, how essential is it that we should study those surroundings minutely, with all the intelligence that has been awakened in the later days of man's history, in order to take the best advantage of them; how important is it that we should look carefully into the real nature of things, so as to avoid an environment that involves a hopeless struggle against the forces of nature, and to choose instead an environment in which the inexhaustible forces of nature will work to our advantage. With the adoption of the evolutionary philosophy, the content of geography can no longer be defined as the relation of earth and man, but as the relation of earth and life. The cleared roadway of a colony of pillaging ants becomes as properly a subject of geographical study as a railroad that connects centres of human population. Elementary geography may still deal with the simplest salient facts and place man conspicuously in the foreground; more advanced geography may include

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examples of greater complexity, but always selecting important rather than trivial matters; but the investigator must study the trivial items along with the greater ones, and all must be duly scrutinized, described and classified.

4. *Physiography and Ontography.*—Let it then be here agreed that the whole content of geography is the study of the relation of the earth and its inhabitants. We thus see two prime divisions of the subject. One includes all the elements of the physical environment of life; the other all those responses which life has made to its environment; and in accordance with modern methods both of these divisions should be treated under the explanatory principles of evolution, inorganic and organic. It is the element of relationship between the physical environment and the environed organism, between physiography and ontography (to coin a word), that constitutes the essential principle of geography to-day. Mature, fully developed geography therefore involves the study of physiography and ontography in their mutual relations. Treated otherwise, the divisions of the subject lose coherence; they fall apart and are gathered up by various other sciences. It is only when they are bound together by the element of relationship that they constitute a reasonably connected body of study, as well unified a science as any other. In support of this principle, let us turn aside to note—as others have done—how largely the principle of relationship is serviceable in classifying the sciences.

5. *Comparison of Geography with other Sciences.*—All terrestrial substances, inorganic and organic, the study of whose relationships constitutes geography, are also the proper subject of study in relation to composition by the chemist: rock, water, air and organisms are all to be analyzed and classified as compounds. Again, all the activities in the world of geography are the appropriate subject of study in relation to energy by the physicist. Moreover, as fast as geography, chemistry, physics and the other sciences advance, their progress should be duly chronicled by the historian; for it is a sad mistake to imagine that the whole content of history is only the "politics of the past." From the discovery of America by Columbus to the discovery of a narrow flood-plain scroll on the upper Susquehanna by an early backwoodsman; from the migration of races across continents to the settlement of miller by a waterfall, there is no discontinuity. The historian must regard all such facts, great and small, as pertinent to his study of the sequence

of human events, even though he can make explicit mention of the greater ones only. The physicist must bring the behavior of a river in making its flood plains and of a stone in falling from a cliff under the domain of physical law, although he may not make mention of every flowing stream and of every falling stone in his systematic text-book. The chemist must discover all the kinds of changes in composition caused by the weathering of rocks; he must learn the composition of everything from the miller to his flour and his millstone. It is therefore not in terms of the things studied that a science can be defined, but only in terms of the relationships involved in the study. The things with which the geographer is concerned may also concern the physicist, the chemist and the historian; but as far as these things enter into the relation between the earth and its inhabitants, they constitute the content of geography.

It is particularly in relation to geology that geography has been needlessly confused. Geology is essentially a historical study; it is for the earth what history is for man. Geography, on the other hand, is distinctly not a historical study; what is often called historical geography might be much better called geographical history. Geography considers the relationship of existing conditions, inorganic and organic; and as far as the dimension of time enters into geographical methods, it is introduced not for the purpose of studying the sequence of events that lead up to existing phenomena—that belongs to geology or to history—but for the purpose of better seeing the existing phenomena themselves, as will be more fully shown below. Thus understood, geology and geography are closely related; it may be fairly said that geology culminates in geography, and that all geology consists of a sequence of paleogeographies. Surely, no geologist would dismiss the present condition of the earth and its inhabitants from consideration as constituting the last page in the recent chapter of historical geology. Ocean navigation and cable laying, city growth and railroad building deserve a place in the geology of the recent period on exactly the same ground that trilobite tracks and dinosaur prints belong in the record of the past. Conversely, every geographer should conceive all the geological history of the earth as involving a succession of geographies, horizontally stratified with respect to a vertical time line. All the processes of slow erosion, of volcanic eruption, of rising and falling lands, of organic adaptations, formed elements of

these successive paleogeographies, just as the slow depression of the Netherlands, the eruptions of Vesuvius and Pelee, the washing of neglected fields, and the migrations of Europeans into the open lands of America constitute elements of the geography of to-day.

The science of geography is therefore, like all other sciences, concerned with the relationships of things which, when they enter into relationships of other kinds, belong under other sciences, and which are known to be pertinent to geography not by their own qualities but by the relationship in which they are considered. It is the classification of the elements of a subject thus constituted that we have to consider.

It is not my purpose however to present here a detailed statement of a classification, but rather to set forth the nature of a classification which might, when expanded in a more technical geographical publication, afford suitable categories for all kinds of geographical facts. It will suffice therefore to indicate briefly the larger divisions of the subject, and to pursue only one of these divisions, namely the lands, into details.

6. *Subdivisions of Physiography.*—Geography as a whole has already been shown to consist of two chief divisions, physiography and ontography. Physiography has four chief subdivisions—the earth as a globe, the atmosphere, the oceans and the lands. Let us set aside for the present all but the last subdivision. The lands should first be treated as a whole, and their contrast with the other exterior parts of the earth considered. A notable contrast, of great significance in its ontographical relations, is found between the lands covered by the atmosphere, and the sea floors covered by the oceans. The latter are monotonously cold, dark and quiet, as well as remarkably uniform in shape and constitution; while the former exhibit a variety of forms, such as high and low, smooth and rugged, flat and steep, and experience a succession of changing conditions, such as wet and dry, calm and windy, hot and cold. The general weathering and washing of the lands, whereby their waste goes to make the gain of the sea floors, results in their being scored by many branching systems of valleys; this highly specialized kind of inequality being as significantly characteristic of the land surface as is smoothness of the blanketed sea floors. There is nothing new in all this, but geographers too generally fail to recognize these general features of the lands as the determining physical environ-

ments in response to which many an organic condition has been called forth.

The lands need subdivision into relatively small areas, for their forms vary greatly from place to place. It has long been habitual with geographers to describe and classify these forms empirically; but there is to-day a well-defined trend of opinion in favor of rational, evolutionary or explanatory description and classification, even though this more modern method has not yet found general acceptance in practical exploration. An eclectic system of subdivision, based on the suggestions of various writers, may be briefly stated as follows:

7. *Classification of Land Forms.*—Land forms are classed first as to kind, according to their rocky structure; thus one area may be of horizontal structure; a second may consist of broken and tilted blocks; a third may have a domed structure; a fourth may be folded; a fifth may be of volcanic origin, and so on.

Each kind of land form is then to be further classified according to its stage in the cycle of erosion, to which it is introduced by initial processes of deformation and (relative) upheaval, and through which it progresses by the action of weathering and washing towards an ultimate goal of obliteration in a featureless plain close to sea level, or in a smooth platform at an undetermined depth beneath sea level. There is to-day abundant warrant for asserting that the sequence of developmental stages through this destructive cycle of erosion is remarkably systematic, and that very effective description of land forms may be given by characterizing them simply as young, mature or old. This is therefore not a matter of abstract theory, but of practical convenience to the field geographer.

There is need of distinction between the inert land mass, offered to erosion by the telluric forces of upheaval, and the physiographic agencies by which the erosion is accomplished; the chief of the latter being river systems. There is again need of discriminating the forms assumed by the slow-moving waste of the land on the way to the sea, from the inert land mass on the one hand, and from the more active agencies of erosion on the other hand. With respect to the active water streams, the land waste is relatively inert and passive; but with respect to the inert underlying rock mass, the waste may be treated as part of the superficial river system. The latter treatment brings forth many interesting homo-

logies between water streams and waste streams, and from this arises a simple terminology for waste forms by which the power that words have of suggesting things is greatly increased.

It is still further necessary to distinguish between the several kinds of agencies that are chiefly responsible for erosion, as determined by climatic conditions. Thus far, a normal climate has been assumed, of sufficient rainfall to fill all depressions to overflowing and of insufficient snowfall to form glaciers. On one side of this norm there is the arid climate, where rainfall is small and vegetation scanty, and where the wind therefore takes a significant part in the work of shaping the land surface; here the whole surface swept by the wind corresponds to the bed of a water stream. On the other side is the glacial climate, where precipitation is chiefly in the form of snow and where drainage is chiefly in the form of glaciers; here the slender and nimble water streams of the normal climate are replaced by clumsy and sluggish ice streams, with the result of greatly increasing the proportion of drainage channel to drainage area.

Finally the border of the lands where they dip under the sea is attacked by waves and currents and appropriately carved; the cycle of shore erosion being just as systematic and helpful as the cycle of rain-and-river erosion. Each kind of land form, as determined by its rocky structure, exhibits forms peculiar to itself and appropriate to their stage of littoral erosion. Here, as in the normal and special cycles of subaerial erosion, such terms as young, mature and old are highly suggestive because of the systematic correlations of various elemental forms that they imply.

This system of classification is at present by no means fully developed, for it has been directly applied to but a relatively small part of the lands; yet it is so efficient where it has been applied that there is every reason to expect that it will be all the more efficient when it shall have been more widely applied and more fully developed. Some of its essential features may now be given fuller exposition.

8. *Physiographic Classification involves Explanation.*—Explanation of origin is regarded as essential to a complete description in this evolutionary method of physiographical classification. Not only must forms of simple and manifest origin, such as sand dunes and stream gorges, be explained; but all forms, difficult and obscure as their origin may be, must if possible be brought under

explanatory treatment. Geographers have been slow to accept this responsibility. True, they have long explained volcanoes by eruption, because eruptions have been witnessed; yet they have been habitually inattentive to the radial gorges by which extinct volcanoes are scored. While gorges and water-gaps are still sometimes ascribed to fractures and floods, most geographers of a fair degree of training explain them more wisely as the result of slow sawing by the streams that flow through them; yet most geographers are still accustomed to adducing a canyon and not a peneplain in evidence of the magnitude of the work that can be done by rain and rivers. There is therefore no more wholesome discipline for the field geographer than to insist on the necessity of explaining every part of the land form that comes under his observation. His courage in this respect should be whole-souled rather than half-hearted; and whatever difficulties he may encounter, the success already attained should strengthen his resolution to pursue his task until complete success is reached.

9. *Explanation involves Past History.*—It is evident however that an explanatory method of description involves the consideration of the past history through which land forms have come forward to their present estate; and thus the subject of physiography gains a strong savor of geological methods. Some geographers seem to be disconcerted by this consequence of the explanatory treatment. They appear to think that description through processes of origin involves too serious a trespass on the field of geology, and they therefore give explanation over to the geologist. But there is nothing novel in the trespass of one science upon the methods of another. The chemist is constantly employing physical methods; the astronomer is as constantly employing mathematical and physical methods. Hence no apology is needed if the geographer employs geological methods whenever they serve his purpose. The real point is that these geological methods serve a geographical purpose; the purpose, namely, of aiding the observation and description of land forms, for which the geographer is primarily responsible. Any methods that aid this end are appropriate. Much attention as the geographer may give to process and time as involved in the sculpture of land forms, his interest in these geological elements is not aroused simply from the hope of tracing out the sequence of events that the past contains, but from the expectation, well warranted by abun-

dant experience, of being better able to treat existing land forms by a rational instead of by an empirical method. It is the geologist who studies the past history of the earth as an end in itself; it is his duty to unravel all the tangled skeins of earth history, however far back they may lead him. The geographer is concerned with the past not as an end but as a means to an end; and he cares only for so much of it as shall serve his present needs.

10. *Value of Ideal Geographical Types.*—The addition of explanation to the responsibilities of the geographer brings with it the need of idealizing actual forms into type forms, for it is chiefly in terms of type forms that actual forms are in fine described. This is also a discouragement to geographers of the more conservative school, who have thought that geography was concerned only with matters of fact, immediately observable. They must however come to see that direct observation is entirely insufficient for the geographer's needs, for the simple reason that if he recorded only what he saw he would be overwhelmed with ungeneralized items. He must generalize in order to bring the observable items within the reach of descriptive terms, and as soon as he generalizes, the use of idealized types is practically unavoidable. Such types have long been in current use, but they have been too few and too empirically defined for the best results. They need to be greatly increased in number, and at the same time they must be correlated with structure, process and time; for only by following the path of nature's progress can we hope to store our minds with types that shall imitate nature's products. It may be fairly urged that the larger the store of types a geographer possesses, and the more careful and numerous the comparisons with nature by which the types have been rectified, the better progress can the geographer make in new fields of observation.

11. *Service of Deduction in Geography.*—But the geographer who adopts the explanatory methods in a whole-souled fashion will find himself called upon not only to imagine a large series of type forms; he must also call into exercise his deductive faculties and employ them to the fullest, if he would make the best progress in the newer phases of his subject, however purely inductive he has imagined it to be. In setting up a store of types, there is need of deducing one type from another at every step; and it may be confidently urged that whoever hesitates to recognize this principle will fail of his effort to describe through explanation. But as a

matter of fact, geography has some time been more deductive than geographers have supposed it to be; and the newer phase of the science is not characterized so much by introducing deduction for the first time, as by insisting on its whole-souled acceptance as an essential process in geographical research.

It is only by giving the fullest exercise to the faculties of imagination and deduction that the cycle of erosion becomes serviceable. Here the geographer who hesitates is lost. Not only should the ideal cycle be followed in imagination through all its gradual changes on a large variety of structures, but the special cycles of arid and of frigid climate must be similarly treated; and then each of these cycles must be broken up by earth-movements into partial cycles and episodes. It is only in this way that the scheme of the cycle gains a serviceable elasticity; and it is highly significant that among those geographers who find the conception of the cycle unfruitful is one who has, with more candid indication of his unexercised imagination than he may have supposed, likened it to a "strait jacket."

Those who have not attained some fluency in the verbal translation of the various stages of normal and special, simple and interrupted cycles can have little understanding of the practical aid that is derived from this method of description. The empirical geographer, unsupplied with a store of carefully imagined and well-defined type forms, sees only what is before him in the field—if indeed he sees so much as that. The geographer who calls the faculties of imagination and deduction to his aid, draws from his mental store one type after another in the effort of matching the explained ideal forms with the actually observed forms. Thus comparing the partial view of the landscape, as seen by his outer sight, with the complete view of the type as seen by his inner sight, he determines, with great saving of time and effort, just where his next observations should be made in order to decide whether the ideal type he has provisionally selected fully agrees with the actual landscape before him. When the proper type is thus selected, the observed landscape is concisely and effectively named in accordance with it; and description is thus greatly abbreviated. It goes without saying that this relatively advanced stage of investigation is not to be reached hastily; that abundant and elaborate description of actual and of type forms in empirical terms, without a trace of explanation, should be demanded of the tyro who aspires to become an

expert; for in no other way can proper training in the use of types be secured.

12. *Contrasts of Biological and Physiographical Classifications.*—It may be worth while to note explicitly that there is little resemblance between the basis of the physiographic classification of land forms, here outlined, and the phylogenetic classification of organic forms now in vogue. In the latter case resemblance is inherited by actual derivation from common ancestors; and if similar forms arise as a result of similar environment, independent of relationship by descent, this only serves to emphasize the rule by pointing to the exception from it. In the former case, resemblance is due to repetition of physical conditions, and inheritance naturally has no part to play. Similar structures, acted on by similar processes, at similar rates for similar times will have similar forms; but as structures, processes, rates and times are all variable, it is not to be expected that identical forms should be developed. All the more need, therefore, of developing a method of rational generalization, whereby the essential features of a landscape may be seized upon as the basis for its description, while the insignificant elements of a landscape may be set aside. It should further be noted that while hybridization is of very limited range among organic forms, there is no limit to it in land forms. All sorts of structures are combined in all sorts of ways and acted on by all sorts of processes at various rates for different periods. This is indeed one of the chief causes of difficulty in physiographical description. Without free crossing of species, the variety of landscape would be much lessened. Physiography would then be easier and less interesting than it is now.

13. *Examples of Explanatory Description.*—The flood-plain scrolls illustrated in Fig. 1 may be instanced as examples that come very easily under the explanatory description of land forms. It has been ascertained with a high degree of certainty that a winding river, revived to renewed downward corrosion by the uplift of its basin, will increase the radius of curvature of its bends and push every bend down-valley while it is cutting down to grade with respect to its new baselevel. If the river had a meandering course when the uplift occurred, the increased width of the meander belt will be shown by the gentle slope of the spurs that enter each meander, as well as by the abrupt bluffs by which each meander is enclosed; while the down-valley advance of the meander system will be shown by the extension of the enclosing bluff with decreas-

ing height along the up-valley side of each spur, so that the spurs have an unsymmetrical cross section as shown in the figure. No flood-plain is developed before grade is reached; but as soon as this delicately organized condition is attained, further valley deepening is practically stopped, although the meander belt continues to widen, and the curves continue to advance slowly down-valley. As a result, narrow strips of flood plain in scroll-like patterns must be developed; a scroll will begin by lapping around the end of a spur; it will then follow along the gentle slope on the down-valley side of the spur and end with reversed curvature shortly after reaching the next enclosing bluff. As time goes on, the spurs are more consumed and the scrolls are widened. The spurs may be trimmed into sharp cusps, and later reduced to blunt cusps, and then the scrolls must have widened into shield-like patterns. As the river swings more and more freely and opens a valley floor of greater breadth than the meander belt, the separate flood-plain shields are joined; further than this we need not trace them here.

Now it is not conceivable that geographical items as systematic as these flood-plain scrolls should be treated empirically, after their origin and their development has once been made out. It suffices in describing the meandering part of the valley of the North Branch of the Susquehanna to say that it has reached the stage of narrow flood-plain scrolls; for on saying this, the sloping spurs and the enclosing bluffs at once come to mind as elements of form that are necessarily correlated with the flood-plain scrolls. The meandering valley of the Rance in Brittany shows a succession of narrow scrolls in the most orderly arrangement. The valley of the lower Seine by Rouen possesses broader scrolls; nearer the river mouth, where the tides run strong, the spurs are greatly reduced. The curving valley of the Evenlode, a diminished headwater of the Thames system in the Cotteswold hills of England, has sharply trimmed spurs which prove that the Evenlode was not beheaded until a somewhat advanced stage of valley development was reached. The diminished stream now straggles irregularly about the open valley floor. The valley of the Lot in southwestern France may be described as having nearly reached the stage of consumed spurs in one cycle, when a moderate elevation introduced a new cycle in which the stage of wide scrolls is now reached. The essential features of the valley are thus concisely indicated, although many individual variations from the suggested type are to be found.

14. *Distinction of Geography from Geology.*—If the explanatory method is adopted as appropriate for the physiographic description of meandering valleys in the narrow scroll stage, the same method should be adopted for all other stages of valley carving and for all other land forms as well. The orderly action of natural processes through a portion of past time is implied in such a phrase as "the narrow scroll stage," and it is similarly implied in saying that the Alleghenies of Pennsylvania are of corrugated mountainous structure, essentially baseleveled in a former cycle; then broadly elevated and thus standing long enough for the weaker strata to be etched out as lowlands, leaving the harder strata to stand up as even-crested ridges; and then again moderately elevated long enough ago for the valley lowlands to have now reached a submature stage of dissection. The descriptions of the Susquehanna valley and of the Pennsylvania Alleghenies differ in the quantity of past process and of past time involved; but such a difference is only of degree, not of kind. If all the stages of development through which the Pennsylvania Alleghenies have passed are traced out for their own sake, as much attention being given to one stage as to another, then the study is truly geological. If the changes of the past are introduced only in so far as they illuminate the present, and with no other object than to secure such illumination, then the study is geographical. It would be as much a mistake to regard such study as geological as it would be to say that a chemist is studying physics when he uses a balance to weigh a precipitate, or that he is studying mathematics when he calculates atomic weights. He is truly enough for the time employing physical and mathematical methods, but he is studying chemistry. It would be no more just to regard the explanatory description of flood plains as belonging under geology because it has to deal with past time, than to treat it as belonging to the study of physics because it involves the application of physical principles in the flow of a stream, in the corrosion of its bed and banks and in the transportation and deposition of detritus; and surely it would be no more appropriate to regard such a study of flood plains as a part of physics than it would be to take away the spectroscopic study of the stars from astronomy.

15. *Dangers of Explanatory Description.*—It is sometimes objected that the explanatory method of description is dangerous, because the observer who seeks to add explanation to observation

may be led to think that he sees things that do not exist. There is certainly some danger of this kind, but it can be greatly lessened by good training—without which the explanatory method is indeed valueless—and in compensation for the little danger that remains, there is the great increase in the thoroughness and accuracy of observation that results from bringing forward the various idealized types to be confronted with the facts in the field. If doubt finally remains, it may be expressed by the phrase, "as if":—The Susquehanna valley looks as if it were in the stage of narrow flood-plain scrolls. The initiated reader is thus concisely put in possession of the most probable conclusion as well as of the doubt that accompanies it. As a matter of practical experience, it may be urged that the gain from attempted explanation far outweighs its danger; and in illustration of this conclusion reference may be made to the curious case of the Connedogwinet, a branch of the main Susquehanna opposite Harrisburg. The branch has an unusually serpentine course, and the tangents between its curves are of extraordinary length. On visiting it in the spring of 1901, I expected that it would show normal narrow flood-plain scrolls; but as a matter of fact, its scrolls were found to be distinctly abnormal, inasmuch as they are nearly all on the down-valley side of the tangents. Truly, this is not a matter of great geographical consequence; the farmers would cultivate the scrolls, on whichever side of the tangents they might lie; but it is certainly of some physiographical interest to note their abnormal position, because it contradicts a generalization that is well supported by the repeated occurrence of examples in various parts of the world; a generalization that is fully explained by simple processes, perfectly accordant with the laws of stream flow. No explanation of the abnormal situation of the Connedogwinet scrolls has yet been suggested; indeed, as far as I have read, no mention of them as abnormal features has ever been made. Their peculiar arrangement seems never to have been noticed until it was brought out as an exception to the rule of flood-plain development. This example may therefore be taken to show that, far from there being serious danger of seeing imaginary facts by the light of theoretical explanation, a well-defined conception of ideal types is a positive aid in correct observation.

16. *Framework of Physiographic Classification.*—If the explanatory method of physiographical description were adopted, it would result in the construction of a mental framework on which all

imaginable types would find their appropriate place in a systematic arrangement. Each of these types might be considered to be the label on a pigeon-hole; and actual examples would be placed in their appropriate pigeon-hole as fast as they were collected. The compartments designed for common examples would soon be filled; while others might long remain empty. Such a plan as this greatly promotes systematic observation, for the very fact that a certain pigeon-hole contains no actual form corresponding to its idealized type urges the observer to search for the missing example in districts where its occurrence is most probable. Revision of an idealized type would naturally be made whenever an example resembling it was found; for however deductive the method of developing types may seem when here stated in the abstract, the actual progress of this sort of study involves repeated oscillations between induction and deduction, in which each process aids the other. The types are therefore not to be thought of as fancy pictures, unreasonably constructed by an ungoverned imagination and arbitrarily fixed by obstinate deduction. They should be the very best imitations of nature that the well-trained mind can construct, and they should be held subject to constant revision and correction as fast as observation is extended.

The conservative geographer will hesitate to construct a framework in which his types shall be more numerous than his examples. Indeed it sounds at first rather presumptuous to say that the variety of idealized types can exceed the variety of nature; but there is no doubt that it can. The earth is after all not so very large; and when all the examples of physiographic items that it contains shall have been studied out and systematically arranged, it will be easy enough to construct imaginary types that belong between two actual examples. Even if all the items that have existed in all the paleogeographies of the earth's history were brought into systematic arrangement, it may be doubted whether they would fill all the pigeon-holes of a well-imagined framework, so easily can the imagination conceive of a type intermediate with respect to any two neighboring examples.

It is therefore plainly a profitable exercise for the systematic geographer to elaborate his systematic framework as far as possible; to increase the number of its little compartments, each bearing an appropriate label; to arrange all the compartments in as systematic an order as he can develop; and to devise every means—verbal,

graphic or mechanical—by which the framework shall always be at his service for practical use. Its value will increase with every step that is taken towards a vivid realization of its imaginary contents. It may seem cumbersome as long as it is unfamiliar; but when it is familiarly known it becomes an indispensable aid in practical work.

17. *Complexity of Geography.*—The whole current of thought changes when the ontographic half of geography is taken up. The training that is here necessary must be gained largely through biological study, while the training for the study of the earth as a globe is associated with astronomy, for the atmosphere with physics, for the oceans with hydrostatics and hydrodynamics, for the lands with geology. Whether this diversity of discipline is an advantage or not need not be answered; it is certainly a necessity. It is perhaps true that geography has, by reason of its many-sidedness, a more complex content than any other science; but if so it merely occupies a rank that would be otherwise held by some other subject; and certainly there is no impropriety in standing at either end of the list in this respect. Astronomy ranks well among the sciences, yet it now calls for mathematical, physical and chemical discipline; and if the change of color on the face of Mars follows his seasons it may be necessary to add a biological discipline as well.

Some have feared that the various parts of geography might fall asunder from their diversity of content and of discipline. So they undoubtedly would, but for the bond of relationship that holds them so strongly together. It may perhaps come to be wise for the geographer to follow the example of those engaged in other sciences and limit his attention to one part of his subject. Just as there are mathematical and physical astronomers, inorganic, organic and physical chemists, students of ancient, modern and many other groups of languages, so there may advisedly be physiographers and ontographers, instead of geographers; but all this is of secondary importance. Geography certainly has its inorganic and its organic side, and both must be understood by any one who would claim to be a thoroughly trained geographer, versed in the relationships by which the physiographic and ontographic sides of the subject are held together. The reason that so few persons can to-day rightly claim such standing is not so much because there is any inherent difficulty in the subject on account of its breadth and its complexity,

as because the subject is not maturely developed; but this is an aspect of the question that I shall elsewhere consider.[1]

18. *Relation of Physiography and Ontography.*—Unlike physiography, which has been recognized as an essential constituent of geography for many years past, ontography has to-day hardly gained an established position. It is best represented in Ratzel's *Anthropogeographie*, but this subdivision of the science is concerned only with the human element, and that is manifestly but a part of the total content of ontography. It is approached in ecology, but none of the many definitions of that term cover all that is here intended, for ontography is meant to include all the responses of organic forms to their physical environment, whether in physiological structure, in individual behavior, or in racial habits. Whether there is need of this new term, whether it will survive or not, it serves a present purpose in bringing clearly forward the organic half of the geographical whole.

The subdivision and classification of ontography has not yet been well accomplished. Before it can be well done, there must be much searching; but we may look forward to a time when all ontographic items shall be arranged on an ontographic framework, in which every compartment shall have for a label what biologists might call a type response. I am persuaded from much profitable experience with the physiographical framework that a corresponding advantage will come from the construction and familiar use of a similiar framework for ontography. Still more: the two frameworks might be brought face to face, and lines might then be drawn between them, connecting cause with effect, effect with cause. If then a plane were passed secant to all these lines of relationship, all the content of geography might be projected along the lines upon it. If the plane were placed near the physiographic framework, there would be groups of points, where numerous radiating lines departing from some dominant physiographic control pass through the plane on their way to various ontographic effects. If the plane were passed near the ontographic framework, the grouping of numerous points of intersection would serve to indicate those organic forms which respond to many physiographic controls, while isolated points would indicate forms that respond to few. Accord-

[1] National Association for the Scientific Study of Education, Proceedings of the Minneapolis Meeting, July, 1902.

ing therefore as the geographical plane is placed nearer to one framework or to the other, the presentation of the total subject might be made primarily physiographic and secondarily ontographic, or the reverse.

19. *Subdivisions of Ontography.*—It is not an ontographic classification, but the nature of such a classification that can here be set forth to best advantage. There should be two chief subdivisions; the first includes those responses that were initiated ages ago and maintained by inheritance till to-day because their controls are persistent; the second, those of relatively recent origin. Further subdivision might be made in accordance with the standard classifications of botany and zoölogy, in which the responses of all kinds of plants and animals to physiographic controls would be taken up in their natural order. But in view of the repetition of similar responses in many different classes of organisms, it will be here more convenient to follow a physiographic order in the ontographical classification. Examples of long-inherited responses will be mentioned first.

As inhabitants of an earth whose mass is very much greater than that of all its organic population, plants and animals very generally show a response to the action of gravity in their attitudes as well as in their structure. As inhabitants of an earth whose opaque surface is illuminated from without, the distribution of color in plants and animals is often closely associated with the response to the downward action of gravity. As occupants of an earth whose surface is nearly globular, plants and animals have been allowed a much wider migration than would be possible for the occupants of a very irregular body, on whose surface gravity would vary greatly. None of these responses are doubtful as to origin or difficult as to comprehension; they ought to be introduced in the elementary study of the earth as the globe; and their almost universal omission from that chapter of geography affords immediate illustration of the little thoroughness with which the subject is treated. Perhaps these matters have been omitted because they are regarded as of less importance than the names of the branches of Siberian rivers; but if so, a very singular standard for the measure of importance has been accepted. Many other long-inherited responses to the physical features of the earth as a globe might be instanced, but space is lacking for their presentation.

One of the most universal of all organic habits, that of breathing

free oxygen, must be regarded as the long-inherited response to the presence of oxygen in the free state, whether mixed with other gases in the atmosphere or dissolved in the waters of the ocean. Organs of flight, to-day characteristic of many insects and birds, are extraordinary devices for movement through the air; this may seem a valueless truism to some, but it must be explicitly stated if the ontographic framework is to be thoroughly constructed, and if conscious attention is to be aroused to it. Vocal organs are responses to the extreme eclasticity of the air; human speech may be reckoned among the responses of modern acquisition under this class. The adoption of blue as one of the primary colors of the spectrum is a modern response to the color of the sky; a physiographic fact that has waited long for its ontographic mate. Pollen grains, spores and innumerable microscopic organisms of great importance in the economy of the nature, exhibit in their minuteness a response to the small sustaining power of the winds that bear them about. If climate were here considered as well as these simpler physiographic features of the atmosphere, the number of ontographic responses in this class would be greatly increased.

The greater buoyancy of water than of air has a notable response in the absence of feet among most of the swimming animals of the ocean. The flying animals of the atmosphere, on the other hand, always have legs to sustain them when they alight on the ground from the little sustaining air. The same contrast between water and air must account for the much greater size of the floating inhabitants of the ocean than of the blown-about organisms of the atmosphere. While the more opaque animals of the sea usually have a darker dorsal and a lighter ventral surface, many of the floating animals find relative safety in imitating the transparence of the waters in which they float. It is the monotony of the cold, smooth, dark and quiet ocean bottom that has doomed it to be the home of the less intelligent organisms, while the variety of the lands has promoted the development of the most remarkable instincts and the highest intelligence among their inhabitants.

The separation of the lands into several large continental masses has led to the division of mankind into races; and closely associated with this division into races go many peculiarities of government, religion and degree of civilization. All this is most intimately connected with that phase of ontography commonly called political geography; and yet so arbitrary and irrational is

the traditional classification of geographical topics that the division of mankind into races is commonly taught under physical geography. The races may be fairly enough introduced there as illustrations of ontographical consequences following from physiographical controls; but to regard them as essentially physiographic topics shows a regrettable failure to recognize the essential quality of geographical discipline.

The simple physiographic factor of distance is of great importance. It involves the separation of the people of a race into many families, and thus is a determining cause of difference of language and of many other habits. The unevenness of surface exhibited in mountain ranges is of small measure in comparison to the dimensions of the earth, and yet it suffices to make movement so difficult that the occupants of one valley may have a distinctly different dialect from those in a neighboring valley. How circumscribed would have been the migrations of the earth's inhabitants if the height of mountain ranges were a large part of the earth's radius! The sheet of loose rock waste by which the lands are so largely covered not only supports the growth of plants, but has been adopted as a home by many kinds of animals; and according as the waste is a coarse talus lying on the steep slopes of a young mountain side, or a fine, deep soil blanketing a peneplain, its occupants are of different kinds. Instances of this kind might be extended without number.

Examples of modern responses to physiographic controls are best found in those new-fashioned characteristics of mankind that are seen in sites of settlement, routes of travel, and in the development of trades and of commerce.

Settlements in deserts offer particularly striking illustrations of the dependence of population on water supply. Settlements on rivers are largely determined by head of tide, by falls, and by fords. Settlements on coasts are influenced by protection from the open sea, and by ease of access from sea and land. The routes of trade and commerce are guided by physiographic factors literally at every turn. Straight roads are laid out on plains, but winding valleys are commonly followed in regions of strong relief; tunnels are driven through mountains; short-cuts are made through isthmuses. Here as before, illustrations are endless; yet abundant as they may be, they have not yet been well classified. At the present day, ontography is less developed than physiography.

Many examples are individual rather than generic. It was the shoals remaining where morainic islands once arose that turned the Mayflower northward from a course that might have led her south of Cape Cod to New Amsterdam ; it was the greater height of the mainland where the moraines of Manomet were piled upon it that led the Pilgrims from their first landing at Provincetown to the quiet harbor of Plymouth. The varied course of human history affords innumerable examples of this kind. It would be profitable to make a long list of them, to classify the items thus gathered, and to select the best examples of various classes for presentation as types. A geographer who was well informed regarding such types would undoubtedly be more observant in his travels than many travelers are to-day. He would be continually asking questions and finding answers where he is now silent.

20. *Regional Geography.*—It is in the prevalently unsuccessful treatment of regional geography that the undeveloped condition of systematic geography is made most apparent. It is well recognized in the organic sciences that only after a general understanding of systematic botany or systematic zoölogy is gained can a profitable attempt be made to describe the flora or the fauna of a limited district. The same principle undoubtedly obtains in geography ; yet nothing is more common in geographical literature than an attempt to treat the geography of a certain region before any thorough system of geography has been agreed upon. This error is in the way of being corrected, but it is still a prevalent error. In texts on physical geography, for example, it is still common to find an attempt made to describe the physiographic features of the several continents before any sufficient understanding has been gained as to the nature of physiographic features. The year of study commonly allotted to this subject in the schools is none too long for a sound systematic course, and by no means long enough for the addition of a regional course as well. Systematic physiography may be vivified by the introduction of many well-selected examples from various parts of the world, but there is not time in a single year to present a substantial account of the continents or even of a single continent in addition to the systematic account of the whole subject.

21. *Conclusion.*—The practical conclusion of all this is that it is the nature of geography as a whole, rather than the accumulation of unassorted and uncorrelated items, that demands the attention of

geographers. Careful analysis and arrangement of the content of the subject is as greatly needed as the exploration of unknown lands. It must be remembered, however, that the object of analysis and classification is to render practical aid in the understanding of geographical items, old and new. There should be no hindrance placed in the way of the active pathfinders who seek to enter unknown lands; but there should be every encouragement given to those who believe that some of the unknown elements of geography may be discovered without going far from home.

Stated Meeting, April 18, 1902.

President WISTAR in the Chair.

Present, 16 members.

Letters accepting membership were read from
Dr. John A. Brashear, Allegheny, Pa.
Dr. Andrew Carnegie, New York.
Prof. William B. Clark, Baltimore.
Dr. Hermann Collitz, Bryn Mawr, Pa.
President Arthur T. Hadley, New Haven.
Prof. George E. Hale, Williams Bay, Wis.
Dr. C. Hart Merriam, Washington.
Prof. Theodore W. Richards, Cambridge.
Prof. Felix E. Schelling, Philadelphia.
Prof. Robert Henry Thurston, Ithaca, N. Y.
Prof. Robert S. Woodward, New York.

Mr. Thomas Willing Balch presented, on behalf of his brother and himself, the MS. account book of the first "Philadelphia Assembly," 1748, and read a note thereon.

Mr. Alden Sampson read a paper on "The Ruins of Palmyra, with a Brief Consideration of the Ancient Estate of that City."

THE FIRST "ASSEMBLY ACCOUNT" —PHILADELPHIA, 1748.

BY THOMAS WILLING BALCH.

(*Read April 18, 1902.*)

John Swift, a Manager and the Treasurer of the First Assemblies, was the eldest child of John Swift and Mary White, his wife, of London. He was born in 1720. He went to England together with his younger brother, Joseph Swift, where they visited their uncle, John White, of Croydon, now a part of London. Returning to America in 1747 he was, as a merchant of Philadelphia, very successful. He was a member of the Common Council from 1757 to 1776, and Collector of the Port of Philadelphia from 1762 to 1772. During the latter part of his life he lived at "Croydon Lodge," in Bucks County, where he died in 1802 and was buried in Christ Church burying ground, Philadelphia, January 14, 1803.

The Philadelphia Assemblies began in 1748, only five years after the organization of this Society. They are, I believe, the oldest dancing organization in the country, their only serious rival, the Saint-Cecélia Society, of Charleston, dating from several years later. During the winter of 1748, six Assemblies were given under the management of four Directors: Lynford Lardner, John Inglis, John Wallace and John Swift. There is a tradition in the Swift family that the *first* meeting at which the Assemblies originated was held at John Swift's house. There were fifty-nine subscribers in all, and as an invitation was extended to the families of every head of a family who subscribed, probably some two hundred persons were eligible to attend the dances. The subscription was two pounds sterling. In 1879, Mr. Charles Swift Riché Hildeburn, a descendant of John Swift, the Manager and the Treasurer, and Mr. Richard Penn Lardner, a descendant of the first Lynford Lardner, the Manager, presented to the Historical Society of Pennsylvania two documents intimately connected with the First Assemblies. Mr. Hildeburn gave the rules to govern the dances, and Mr. Lardner gave the list of the original subscribers.

A third manuscript relic of those gay festivities is the account book kept by John Swift. It descended through the lineal descendants of John Swift to that learned and accomplished antiquarian and bibliophile, the late Mr. Hildeburn, a member of this Society.

It is a small, thin book, and Mr. Swift used it originally for some of his own accounts, and for some land transactions for his younger brother Joseph. On one cover he wrote: "Account book 1746." When the Assemblies were instituted and his fellow-managers chose him the Treasurer, he turned to the other end of this little book and there kept the "Assembly Account." Owing to age and neglect —indeed, had it not been for the keen antiquarian eye of Charles Hildeburn, it would probably long ago have gone to the paper mill —the Account Book is much worn and somewhat injured. But now it has been treated by an expert, and every sheet covered with silk so as to guard it against any future weathering of time.

An examination of the account shows that the six Assemblies of 1748 were far less costly than the two large balls that are now given annually at the Academy of Music; or, for that matter, even the three balls that were held each season about fifty years ago at Musical Fund Hall. In one respect, however, those old worthies were not behind the present generation, for taking all things in proportion they provided rum liberally. The record kept by Mr Swift is somewhat injured, so that it is impossible to state exactly how much he disbursed, but the whole cost of the six dances seems to have amounted to a little more than £130. As there were only fifty-nine subscribers at forty shillings each, which gave a total of £118, the Managers doubtless, as so often happens nowadays in all sorts of social and philanthropic undertakings, had to put their hands in their own pockets. A few extracts from the expenses show the modest and simple character of the entertainments:

	£.	s.	d.
" pd Mary Dicas for China & Candles as per Acct ending 7th March	8	15	6
pd Mr. Inglis for Sundries	—	19	—
16th [March] pd for Bisket	—	9	6
pd Musick	1	10	—
pd Diana	—	2	6"

And again:

	£.	s.	d.
" pd for 2 Gallons Spirit	—	15	—
pd Sharper 5 nights attendance	—	18	9
pd. Greek for attendance	—	7	6
pd. Mr Inglis for rent	20	—	— "

The Managers of the first Assemblies had to pay a tax, both to the city and to the county, as may be seen by turning to Mr. Swift's Account Book; but as the book is there somewhat torn, it is impossible to know how much.

From the time the Assemblies were first organized to the present, they have continued with pretty general regularity except when interrupted by war or other serious drawbacks. They have been held in various places, and the names on the list of subscribers have changed very much. Many of the Quaker families—such as the Rawles, the Norrises, the Logans, the Whartons, etc.—that owing to their faith kept aloof at first from such gay and frivolous pastimes, later joined in with the Shippens, the Willings, the Swifts, the McCalls, the Hopkinsons, the Lardners, the Francises, the Bonds, the Lawrences, and others who were among the first list of subscribers. And some of the old names *alas* have died out.

It is not inappropriate on this occasion to recall to mind a few of the ladies who took part in those entertainments in the latter half of the eighteenth century. Lieutenant-Colonel Joseph Shippen, a graduate of Princeton, who was elected a member of this Society, January 19, 1768, and who served under Forbes in the capture of Fort Duquesne, and was a generous patron and benefactor of Benjamin West, has portrayed for us a charming picture of some of the belles that reigned supreme at the Assemblies in his day. In the "Lines written in an Assembly Room," which he wrote at least as early as 1774, and very probably in the sixties, he says:

"With just such elegance and ease,
Fair charming Swift appears;
Thus Willing, whilst she awes, can please;
Thus Polly Franks endears.

* * * * * * * *

"With either Chew such beauties dwell,
Such charms by each are shared,
No critic's judging eye can tell
Which merits most regard.

"'Tis far beyond the painter's skill
To set their charms to view;
As far beyond the poet's quill
To give the praise that's due."

The invitation card to the Assemblies for 1790 for Colonel Ship-

pen's daughter Mary—better known as "Polly" Shippen—has been preserved, and reads as follows:

"PHILADELPHIA ASSEMBLY, 1790.

The Favour of Miss P. Shippen's
Company is requested for the Season.

J. M. NESBITT, W. STEWART,
GEO. MEADE, JOS. REDMAN,
JOHN SWANWICK, GEORGE HARRISON,
Managers."

Another card for the season of 1850, when three Assemblies were given at Musical Fund Hall, is thus inscribed:

"ASSEMBLIES.

"The Honor of
Company is requested for the Season.

"JOHN M. SCOTT, THOMAS CADWALADER, JOSEPH SWIFT, CHARLES WILLING, RICHARD VAUX, M. G. EVANS, *Managers.* JAMES H. BLIGHT, B. W. INGERSOLL, WILLIAM T. TWELLS, ALEXANDER BIDDLE, WILLIAM W. FISHER, BERNARD HENRY, JR."

During the Civil War the Assemblies were completely stopped; but after the conclusion of that great struggle they were revived in 1866, at the Academy of Music, by Dr. Alexander Wilcocks, who was a Manager before the war, William Henry Rawle and other gentlemen.

We Americans, in the rush and stress of every-day life, are too apt to forget that those things we enjoy to-day are in a measure due to those who built in an earlier time. It is good to have some reverence for the experiences of the past as we prepare for the future. Charles Lamb, in one of his sonnets, tells us:

"'Tis man's worst deed
To let the things that have been run to waste,
And in the unmeaning present sink the past:
In whose dim glass even now I faintly read
Old buried forms and faces long ago."

While we should not worship what has been so much as to forget

to labor in the present and for the future, we should not be entirely oblivious of those who have gone before. And as unless old papers and books are properly housed in some collection like that of the American Philosophical Society, they are pretty sure in the changes and ups and downs of fortunes of their various succeeding owners to be eventually destroyed, it is with peculiar pleasure, therefore, that in behalf of my brother, Mr. Edwin Swift Balch and myself, I am able to present to the Society the Account Book of the First Assemblies kept by our great-great-great-uncle, John Swift, and so insure its future preservation.

Stated Meeting, May 2, 1902.

President WISTAR in the Chair.

Present, 7 members.

Mr. Benjamin C. Tilghman, Jr., a newly elected member, was presented to the Chair, and took his seat in the Society.

Letters accepting membership were read from

Mr. Grove K. Gilbert, Washington.
Prof. Paul Haupt, Baltimore.
Prof. Albert A. Michelson, Chicago.
Mr. Benjamin C. Tilghman, Jr., Philadelphia.
M. Gaston Darboux, Paris.

Stated Meeting, May 16, 1902.

President WISTAR in the Chair.

Present, 19 members.

Prof. Hermann Collitz and Prof. Felix E. Schelling, newly elected members, were presented to the Chair, and took their seats in the Society.

Letters accepting membership were read from

M. Henri Becquerel, Paris.
Prof. G. Johnstone Stoney, London.

A letter was read from the Comité de l'Exposition International de l'Art et de la Paix, inviting the Society to participate in the International Exposition, to be held at Lisbon in May, on the anniversary of the Conference at The Hague.

The decease was anounced of

Mr. Paul Leicester Ford, at New York, on May 8, aged 37.

President Henry Morton at Hoboken, on May 9, aged 65.

Mr. Stewart Culin read a paper on the Indians of the Southwestern United States.